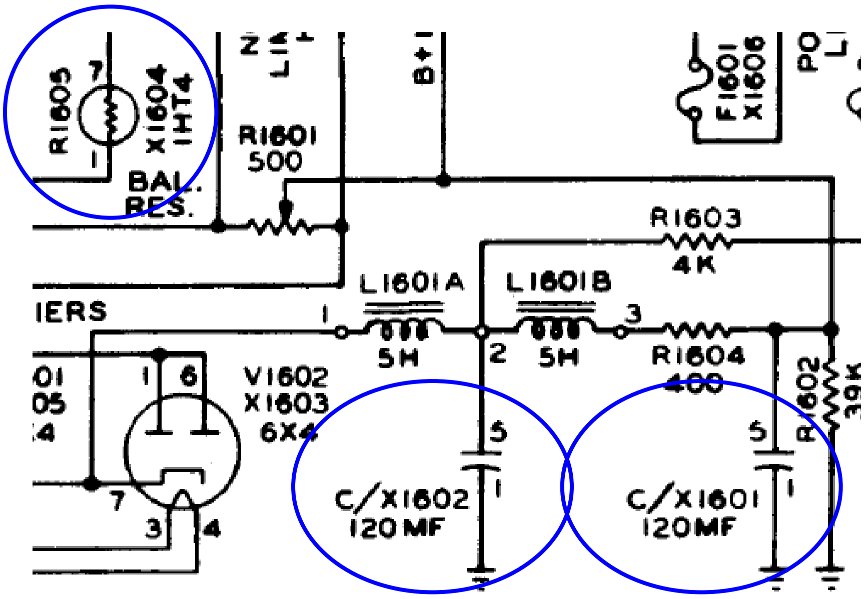
Model Number: AN/FRR-23 Serial Number: 80, By: Virgil Cheng, vr2xgm

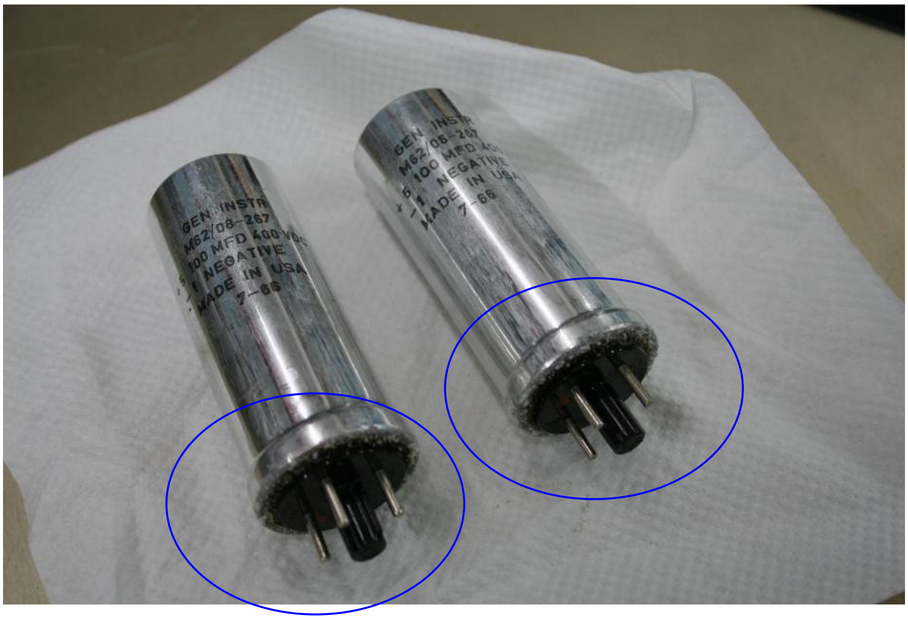
Date: 22-Jul-2006

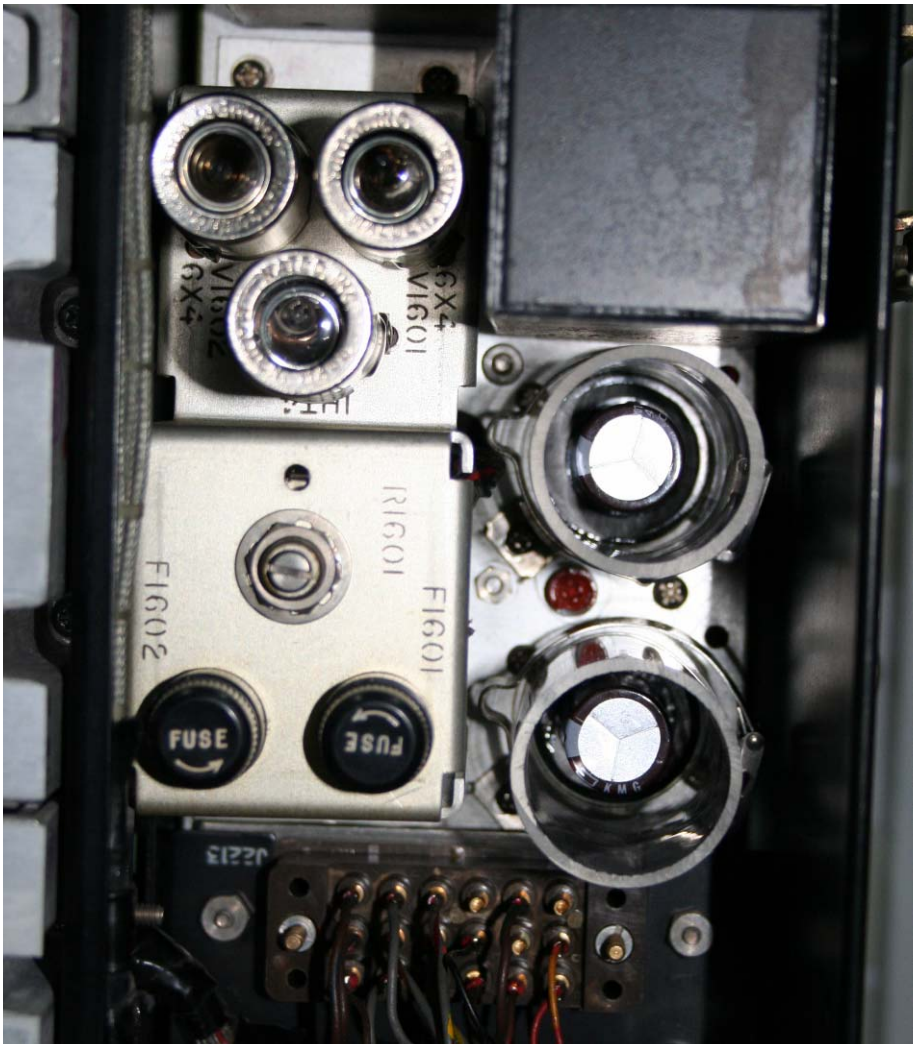
Following problems were discovered during first inspection of the unit.

- R1605 , 1HT4 ballast tube, open circuit



- C/X 1601, C/X 1602 120uF 400V capacitors, high leakage current, reduced capacitance and overheated during powered operation. Sign of serious electrolyte leakage found.

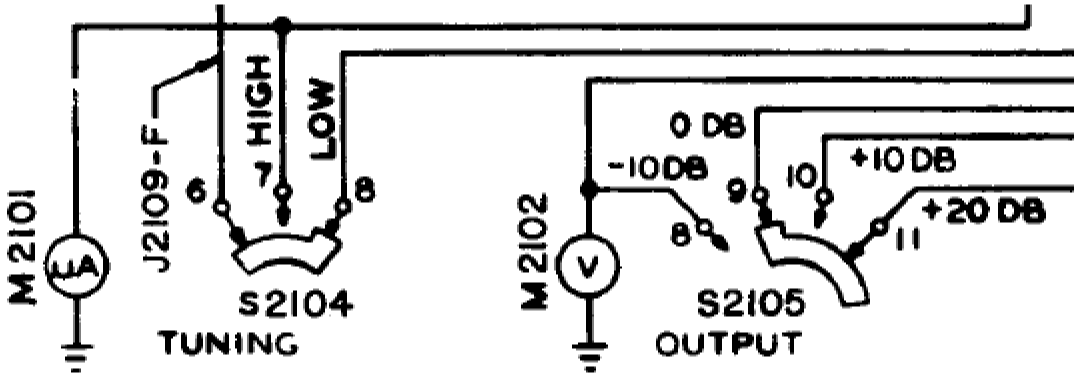




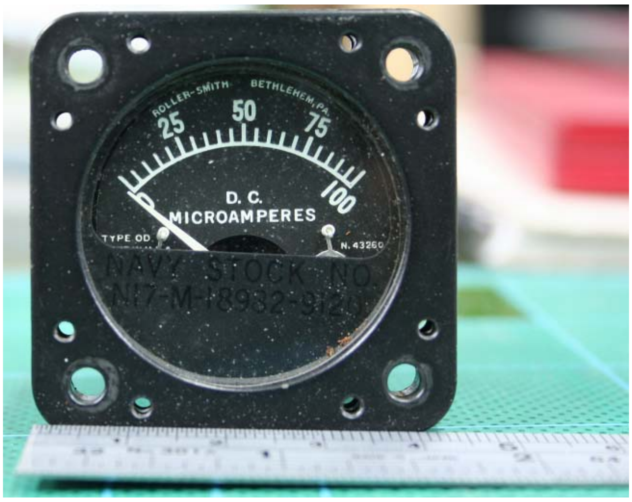
- 1HT4 ballast tube was replaced.

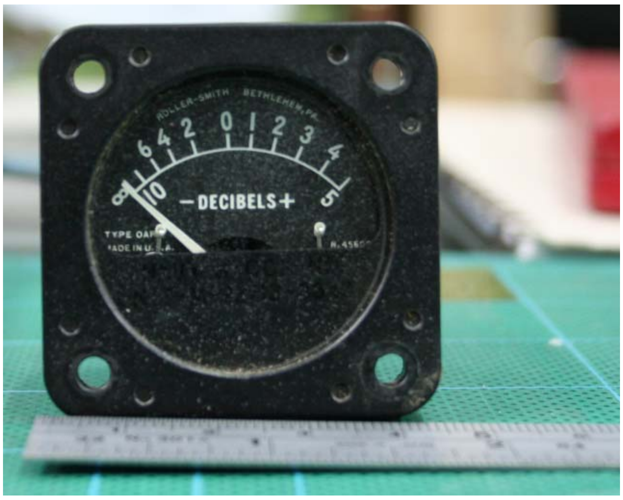
- C/X 1601 and 1602 replaced with two Rubycon 120uF 400V electrolytic capacitors soldered onto GT octal plugs. 35mm diameter Acrylic tube was attached to the Octal plug for ease of handling.

16-Aug-2006

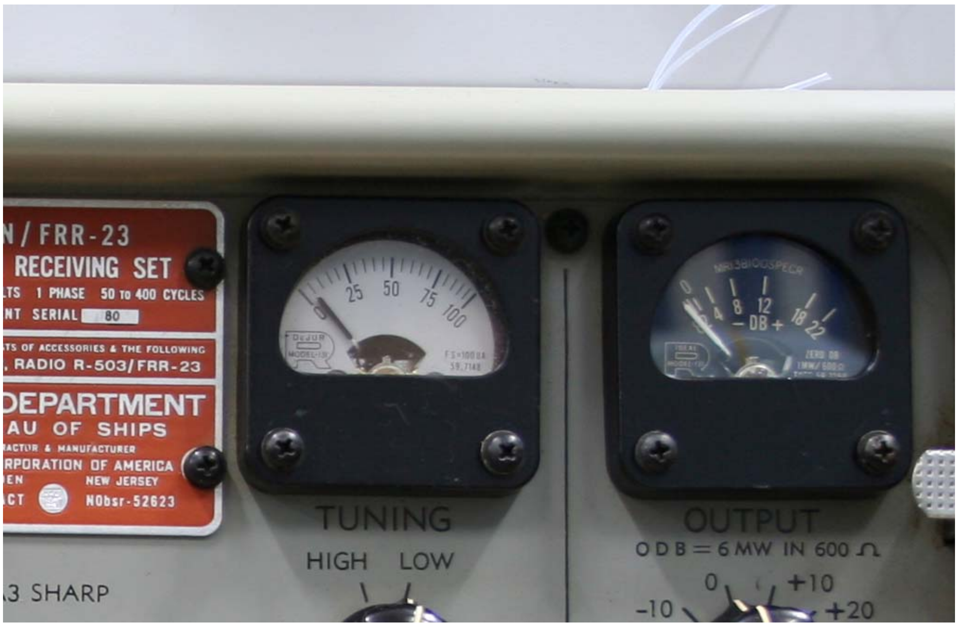


M2101 and M2102 were found stuck, armature coil winding on both meters were found to be corroded and open circuit.





Similar meters were replaced, not identical item.

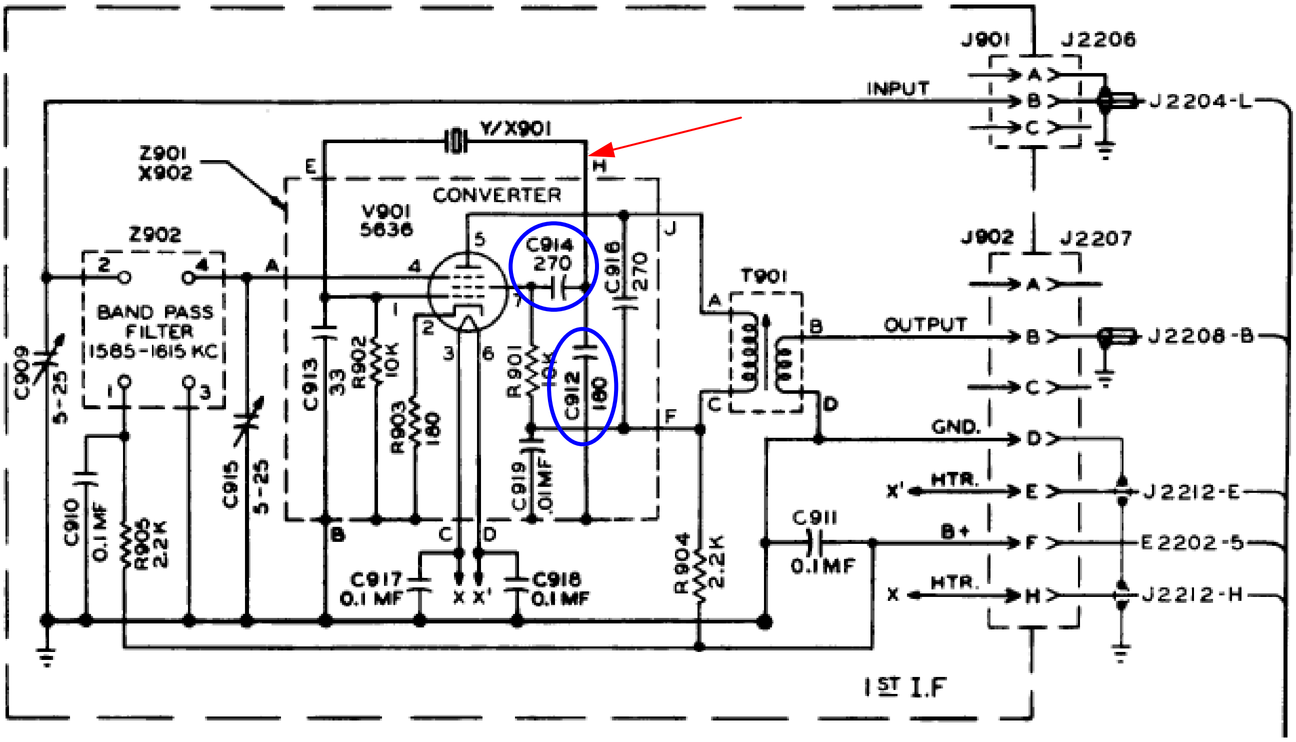


Date: 6-Dec-2006
Symptoms: Cracking noise from audio. Noise has no relationship with receiving signal.
Failure analysis/Serviced items:

Cracking appears in the form of sudden and random variation of signal levels. It typical period is around 1mS to 20mS. Amplitude is also random.

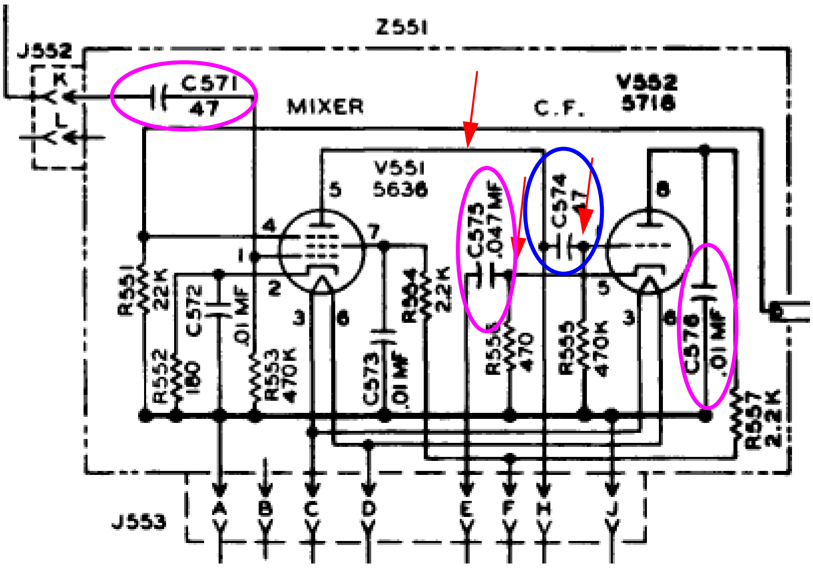
Identical signal level variation consistent with audio noise was also found superimposed on IF output (connector A2) and Panamonic output (connector A3).

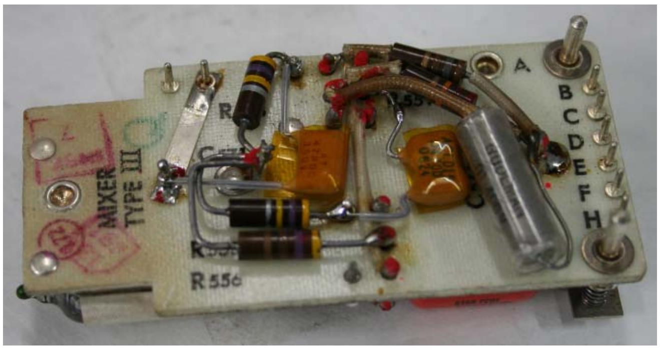
The first origin of cracking noise was found on terminal H of assembly Z901



Random noise was seen superimposed on the oscillation signal of X901. Unplugging X901 does not remove the noise. C914 (270p) and C912(180p) were prime suspects. Both capacitors were removed and checked with a high voltage power supply. They were breaking down when biased with a DC voltage higher than 60V. Both were replaced with 500V rated Silvered Mica capacitors. Problem on assembly Z901 was rectified.

After servicing Z901 cracking noise was not completely eliminated. Noise was still heard from audio and observed from connector A3 panarmonic output.





Noise monitored on connector A3 was traced to the cathode follower output of V552 in assembly Z551. An additional symptom was the signal seen on the Anode of V551 was not duplicated at the Cathode follower V552's output. It appears V552 was not biased correctly. Same noise was seen at pin 1 of V552. Again C574 (47p) was problematic. Removing C574 and tested separately confirms the same breakdown problem. After replacing C574 the noise was significantly reduced. There were still short bursts of cracking noise heard during the first few minutes after power up.

In conclusion the problem was caused by Silver whisker migration of aged Silver Mica capacitors. This imply all Silvered Mica capacitors coupling capacitors in the unit with high voltage bias are considered potentially unreliable and to be replaced.

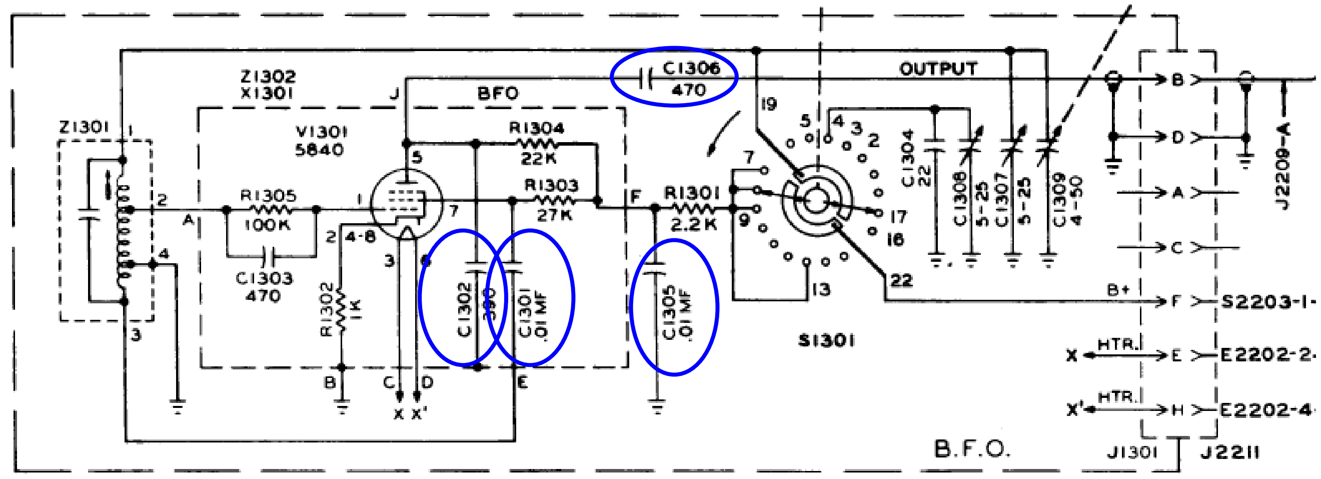
26-Dec-2006

Additional capacitor replacements:

C571 - for future reliability reason, replaced with 47p 350V Silvered Mica
C576 - jacket deterioration, replaced with Vishay 10n 400V Polypropylene
C575 - jacket deterioration, replaced with Marcon 47n 400V Polyester

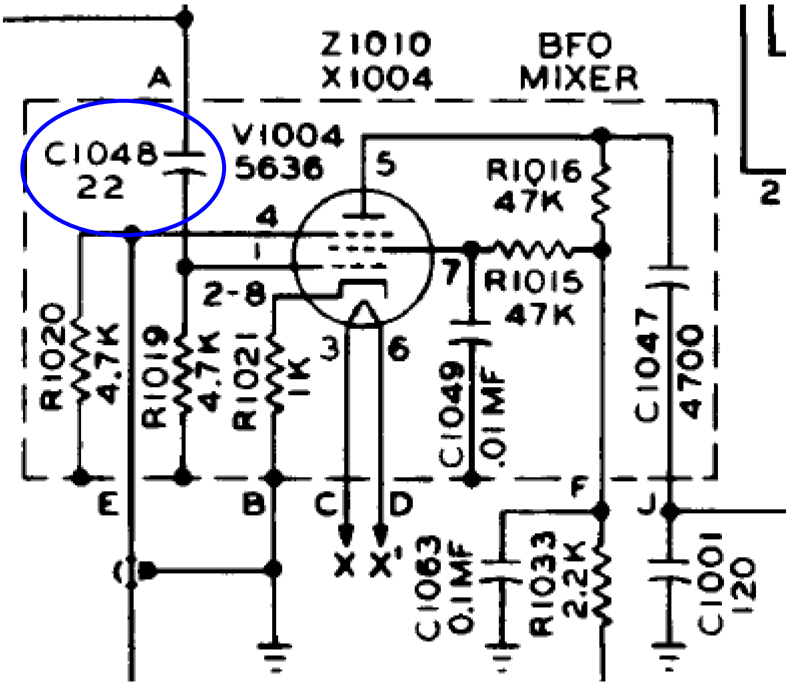
7-Dec-2006

Preventive maintenance was done on BFO assembly, suspicious capacitor were replaced.



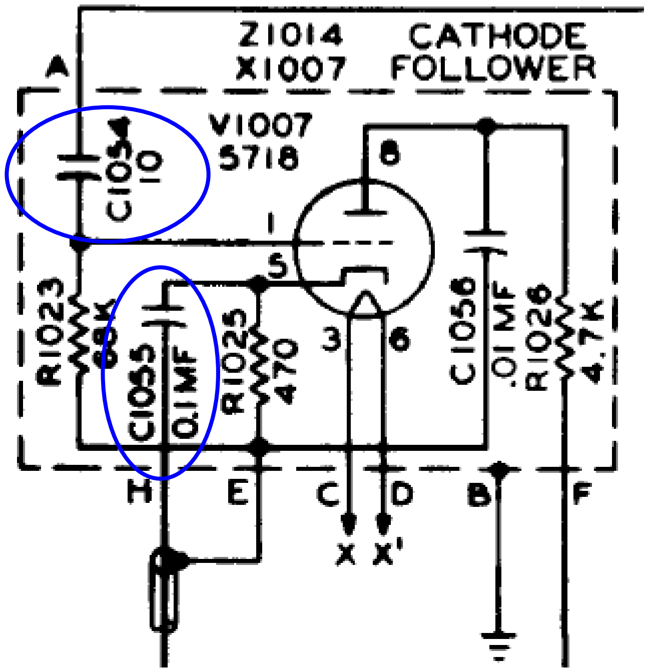
C1302 (390p) and C1306(470p) were replaced with 500V rated part. C1306 was tested normal. C1302 ground side lead has excessive mechanical fatique and broke off from capacitor after a little mechanical stress. Both capacitors tested okay with 120V DC bias. Capacitor C1301 was found to have a deteriorated insulation jacket and was replaced. Jacket was covered with an oily liquid. For reliability reason C1305 was replaced with 0.01uF Polypropylene 400V capacitor.

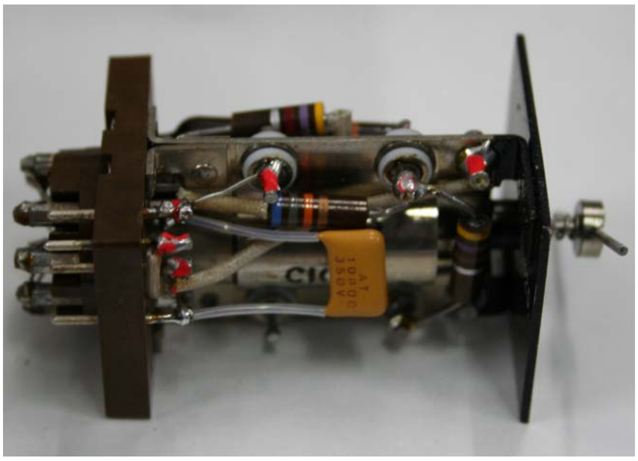
9-Dec-2006

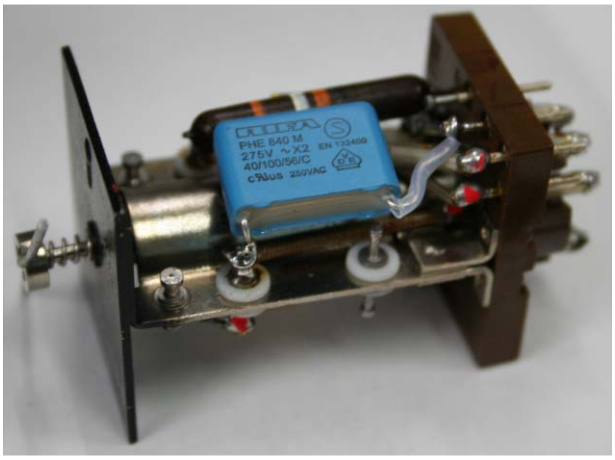


C1048 (22p) inside BFO assembly Z1010 was replaced. This capacitor was tested faulty.

10-Dec-2006



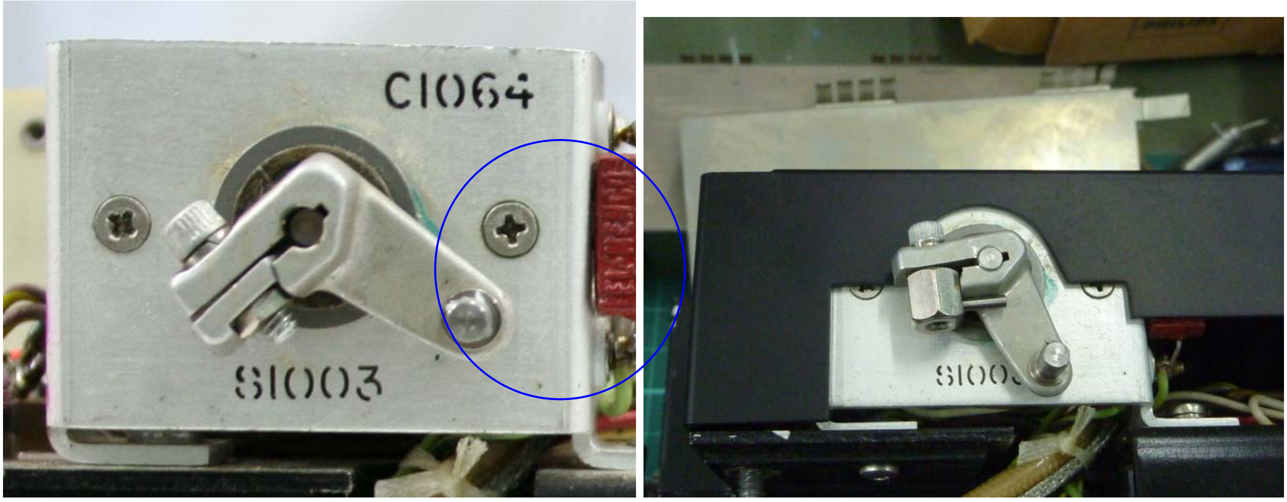




C1054 was replaced with 350V rated part. C1054 was tested faulty afterwards.
C1055 suffered degradation on its insulation jacket and was replaced with a 630V X2 rated Polypropylene capacitor.

Noise burst was practically eliminated after replacement of all capacitors above.

When receiving mode switch was set at A1 BROAD and A1 NARROW, the expected BFO beat was not obviously heard. Problem was traced to a broken rocker arm at S1003 on the 2nd IF amplifier.

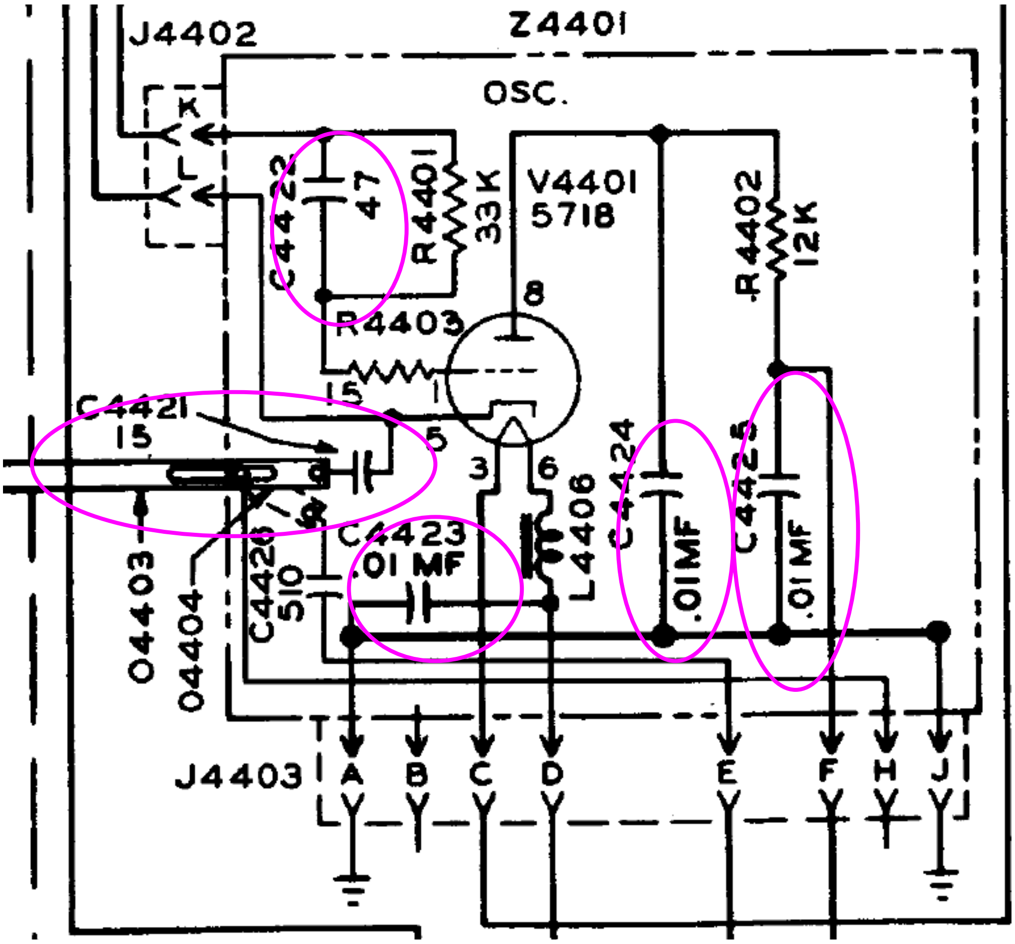


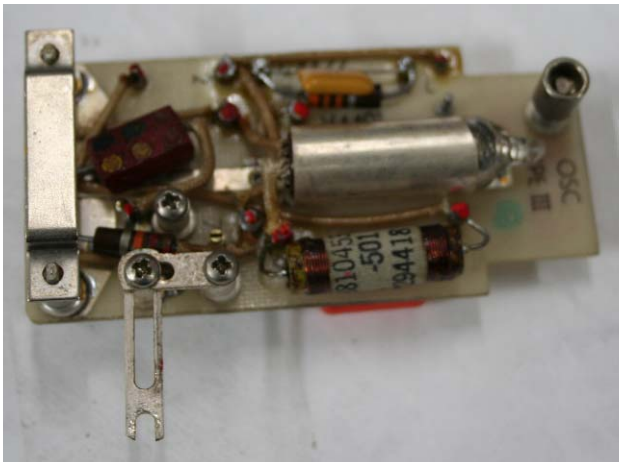
Rocker arm was broken at an inconvenient position. A modified hex nut with a 1.6mm pin insert cut from a high speed steel drill bit was used to provide clamping pressure on the broken rocker arm. The improvised component had just adequate mechanical clearance too allow the rocker arm move freely.

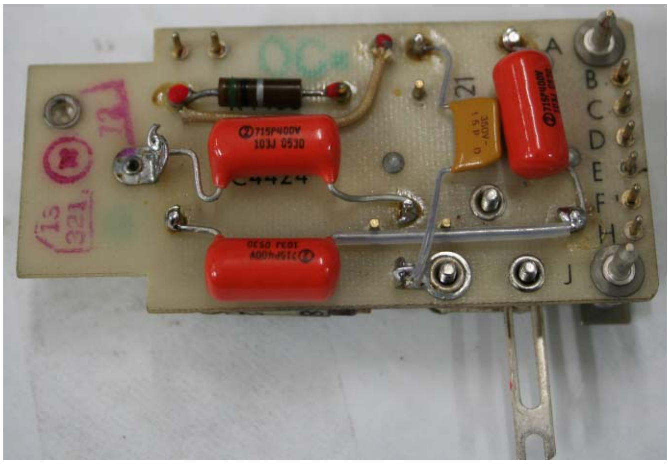
Realignment was pretty tedious due to unclear documentation on the schematic drawings. After circuit tracing, it was believed the schematic drawing is showing selector switch setting with receiving mode switch resting at position A1 BROAD.

26-Dec-2006

Z4401 Local Oscillator module

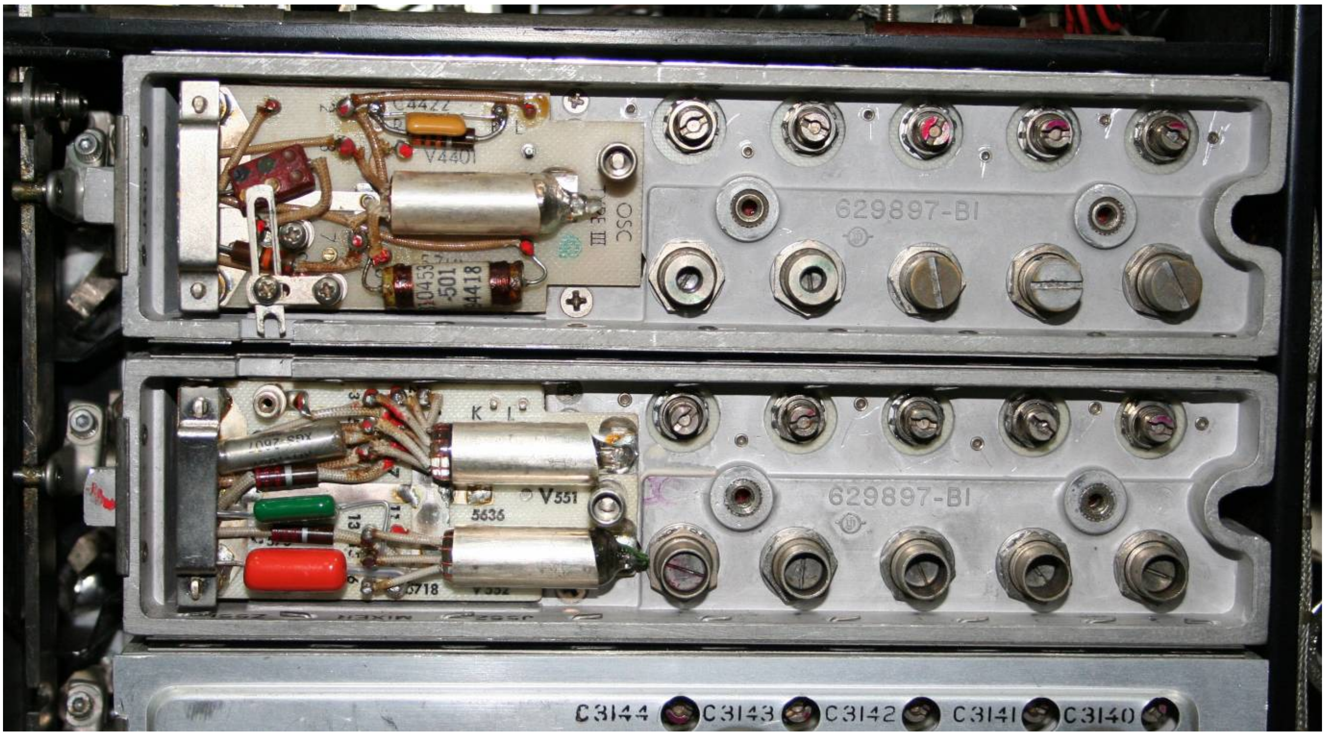


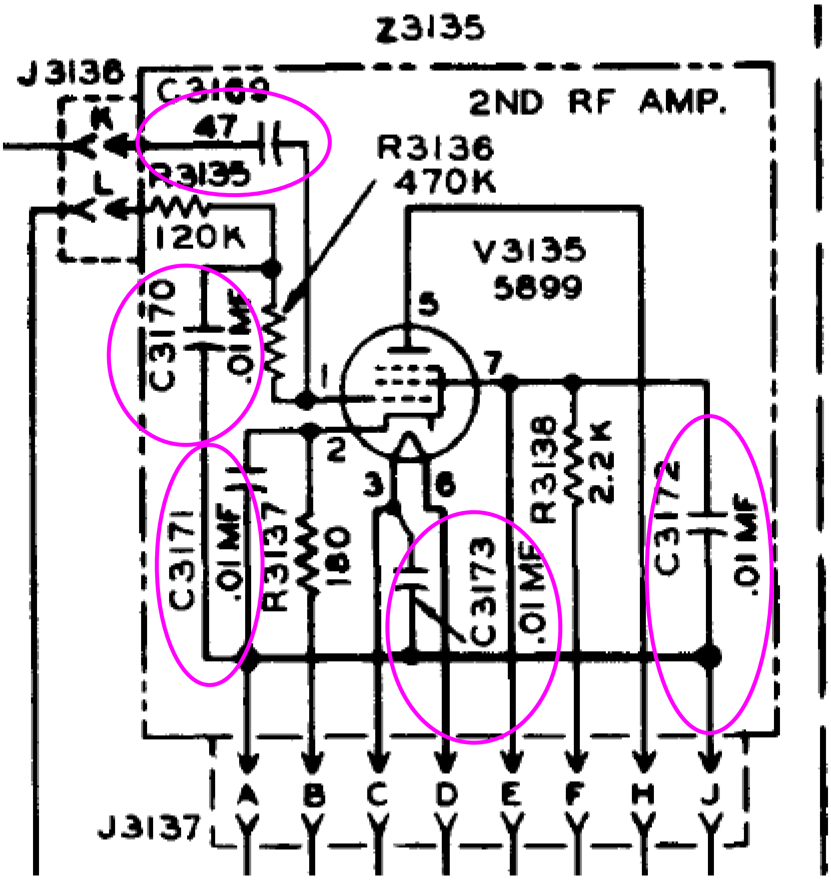


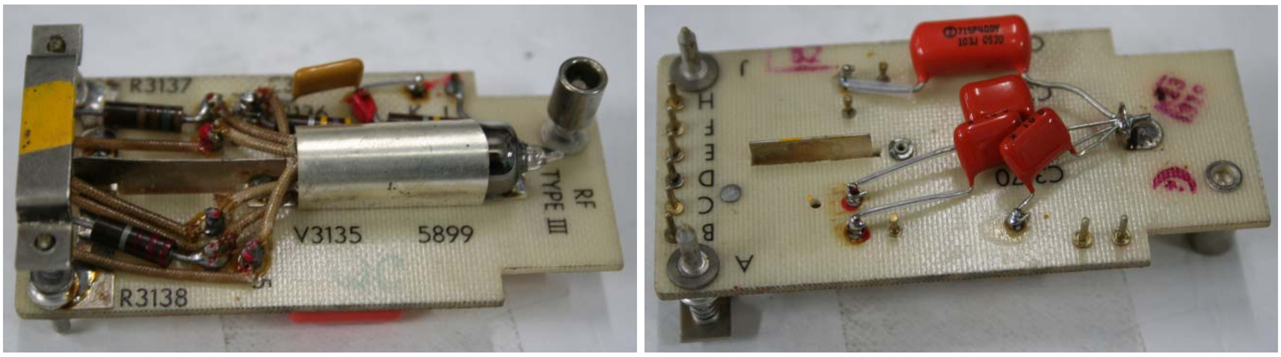


- C4421 replaced with 15p 350V Silvered Mica
- C4422 replaced with 47p 350V Silvered Mica
- C4424 replaced with Vishay 10n 400V Polypropylene
- C4425 replaced with Vishay 10n 400V Polypropylene
- C4423 replaced with Vishay 10n 400V Polypropylene

Photo of serviced oscillator and mixer modules installed in assemblies



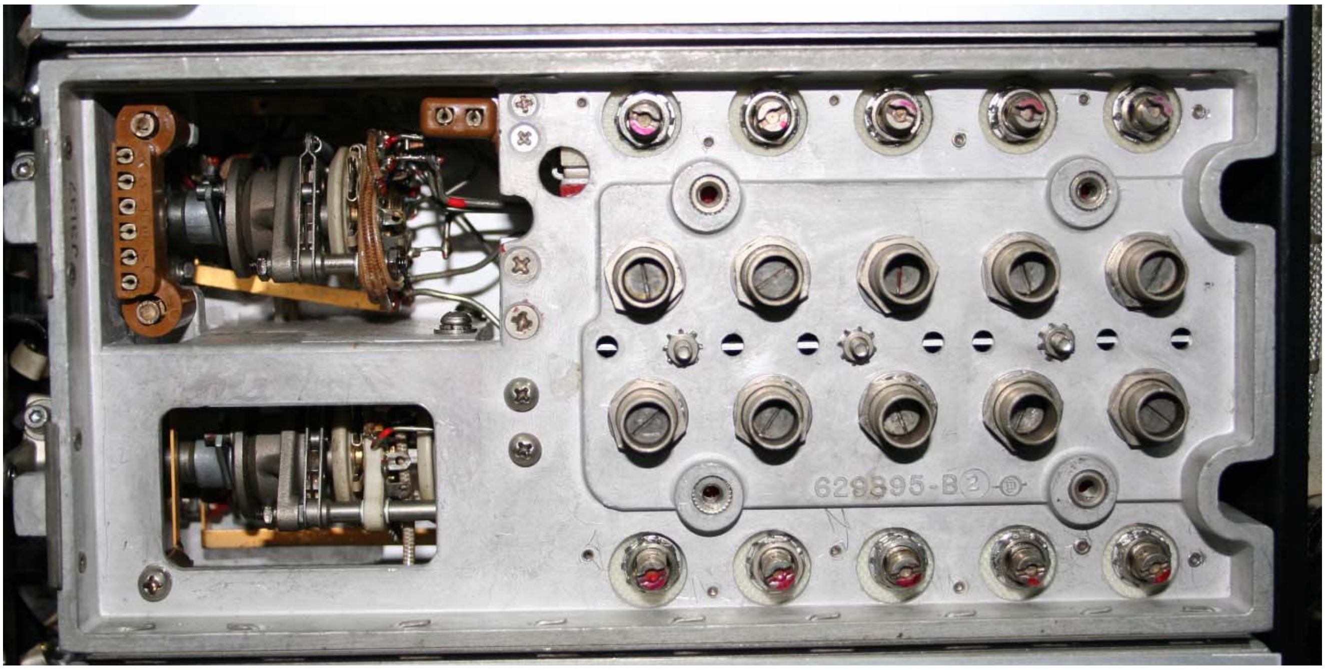


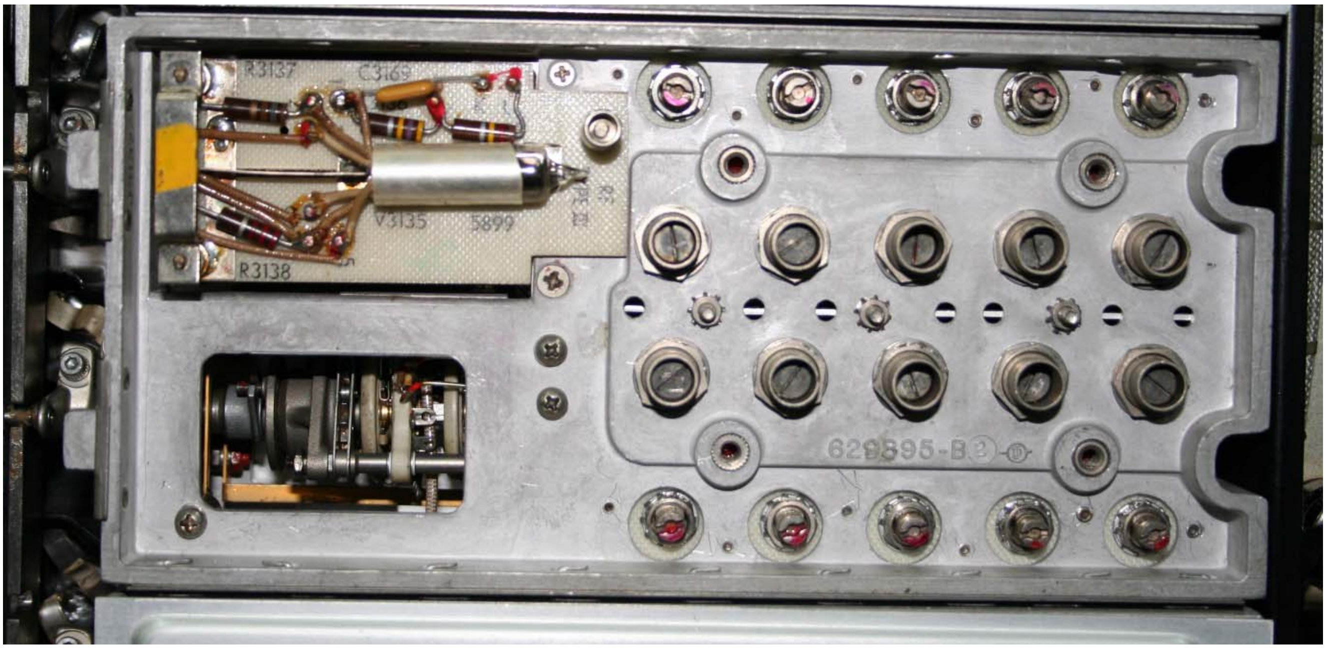


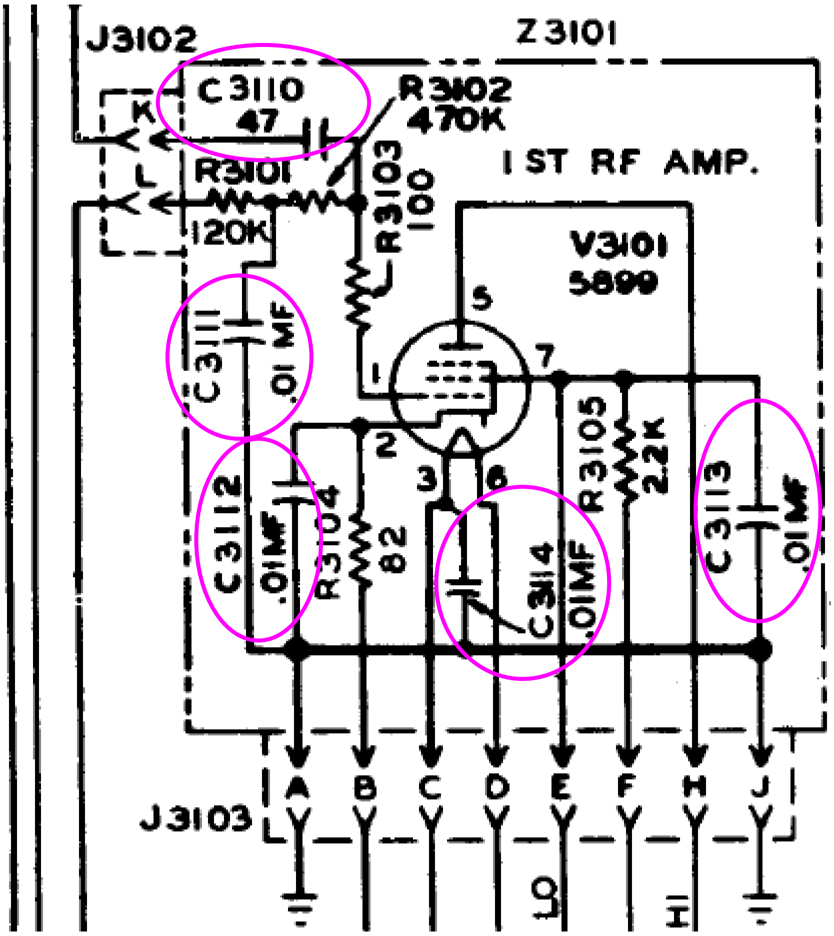
Z3135 Second RF Amplifier module

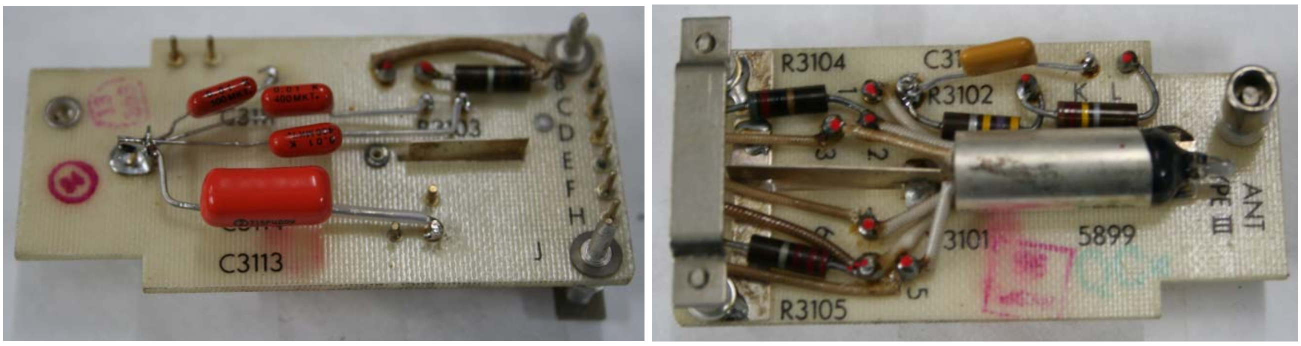
- C3172 replaced with Vishay 10n 400V Polypropylene
- C3173 replaced with Philips 10n 400V MKT polyester
- C3171 replaced with Philips 10n 400V MKT polyester
  later replaced with Murata 10n 50V X7R ceramic axial.
- C3170 replaced with Philips 10n 400V MKT polyester
- C3169 replaced with 47p 350V Silvered Mica

Photo showing 2nd RF amplifier









Z3101 First RF amplifier module

- C3110 replaced with 47p 350V Silvered Mica
- C3111 replaced with Philips 10n 400V MKT polyester
- C3112 replaced with Philips 10n 400V MKT polyester
  later replaced with Murata 10n 50V X7R ceramic axial
- C3114 replaced with Philips 10n 400V MKT polyester
- C3113 replaced with Vishay 10n 400V Polypropylene

13-Mar-2007

Symptom:

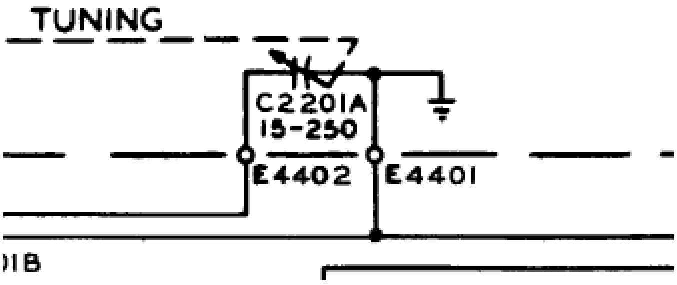
Tuning frequency changes when front panel is tapped

Failure analysis:

Local oscillator frequency drift when:

- Front panel is tapped.
- Chassis modules were tapped.
- Basically any chassis transmitted vibration.

Silver plated Copper ribbons connecting local oscillator tuning capacitor C2201A To terminal E4402 and E4401 are found to be very sensitive to object proximity, E4402 is more sensitive amongst the two.



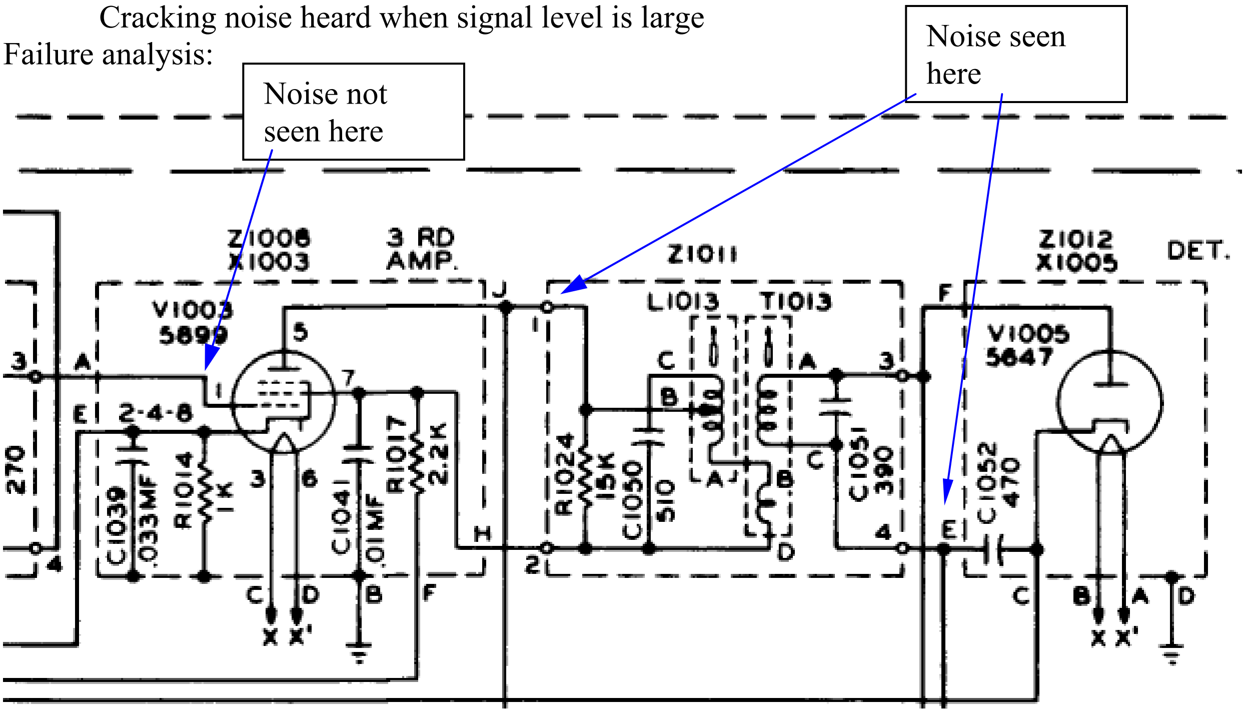
Local oscillator module was disassembled and inspected. No visual damage found. Troubleshooting continued with no accurate fault identification.

13-Mar-2007

Symptom:

Cracking noise heard when signal level is large

Failure analysis:

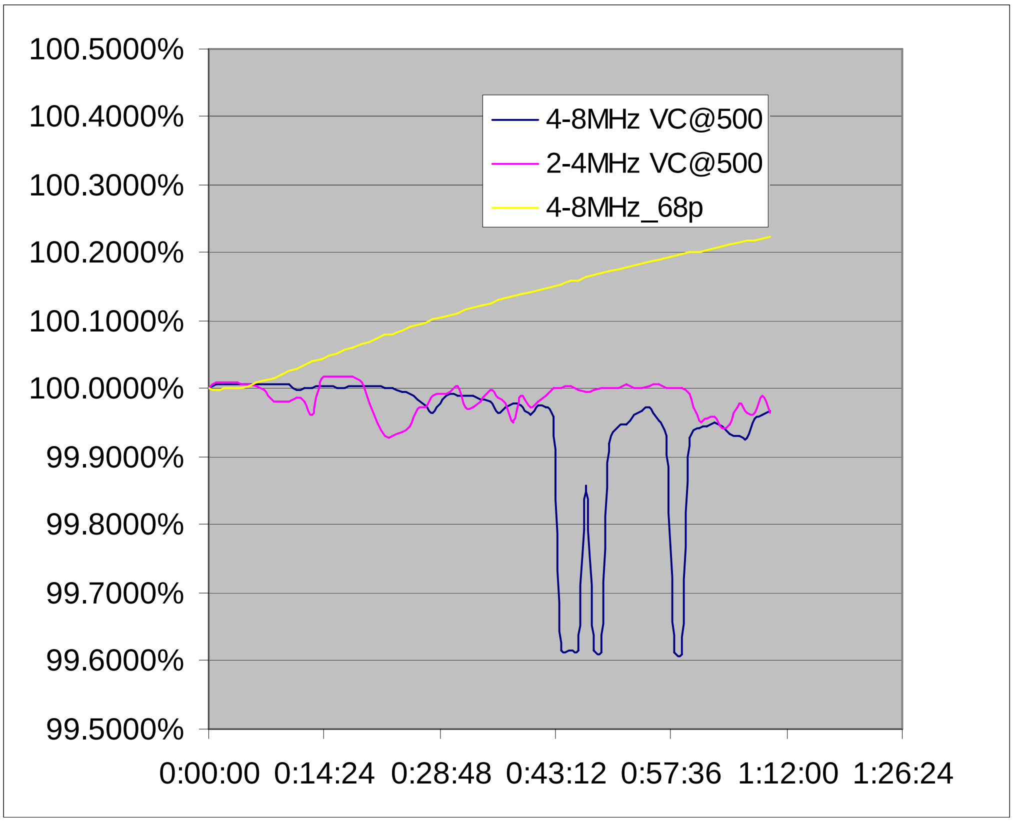

Noise not seen here

Noise seen here

Capacitor C1052 , Silvered Mica, 470p was replaced, suspicion of Silver migration short circuit.

9-Feb-2008

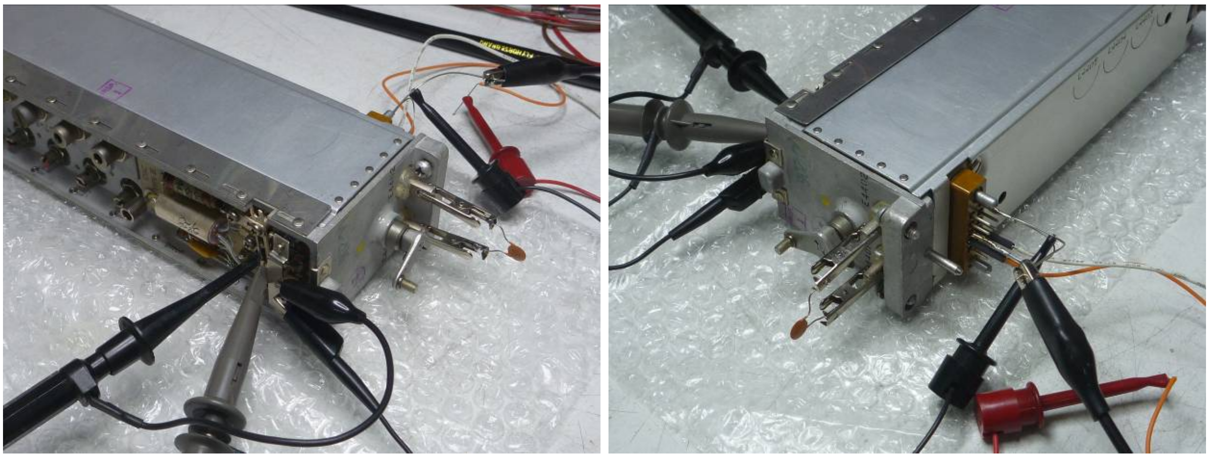
The instability problem first found on 17-Mar-2007 was again investigated. The frequency drift was quantitatively investigated to understand origin of problem. Oscillator frequency vs time was measured with a dial frequency dial setting of 500 and a 68p NPO fixed capacitor as tuning capacitor connected to terminals E4401 and E4402. Measurement was expressed in terms of percentage of normalized frequency.



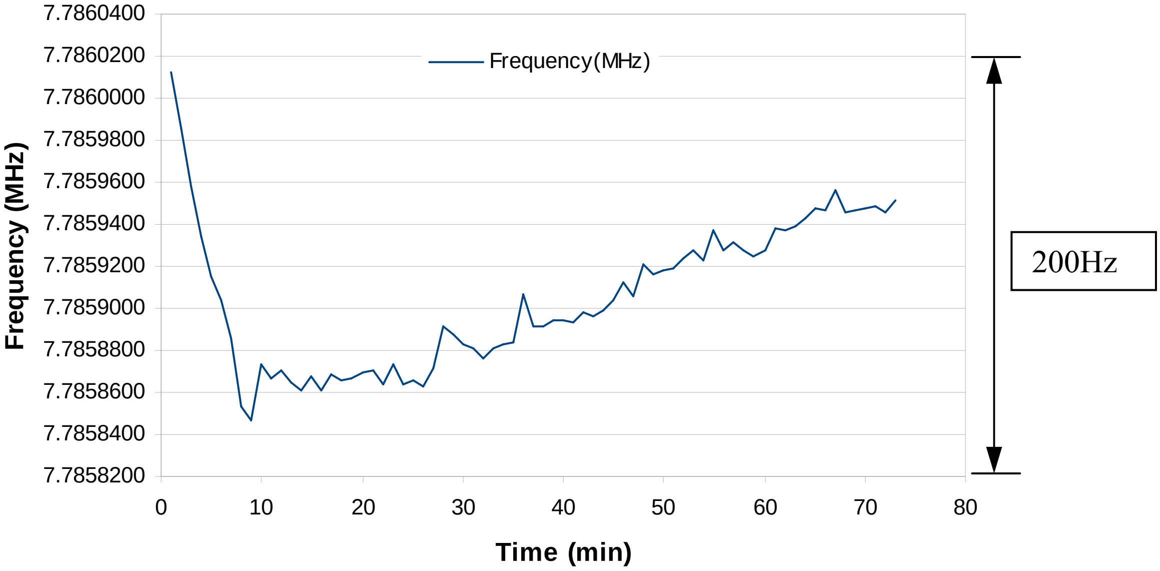
Result showed a depressing conclusion as frequency was generally unstable when oscillator module was connected to the variable capacitor. And from the rapid changes in oscillator frequency, suggested high chance of a mechanical contact problem within the variable capacitor assembly. Since the assembly was sealed. Repair will be quite difficult.

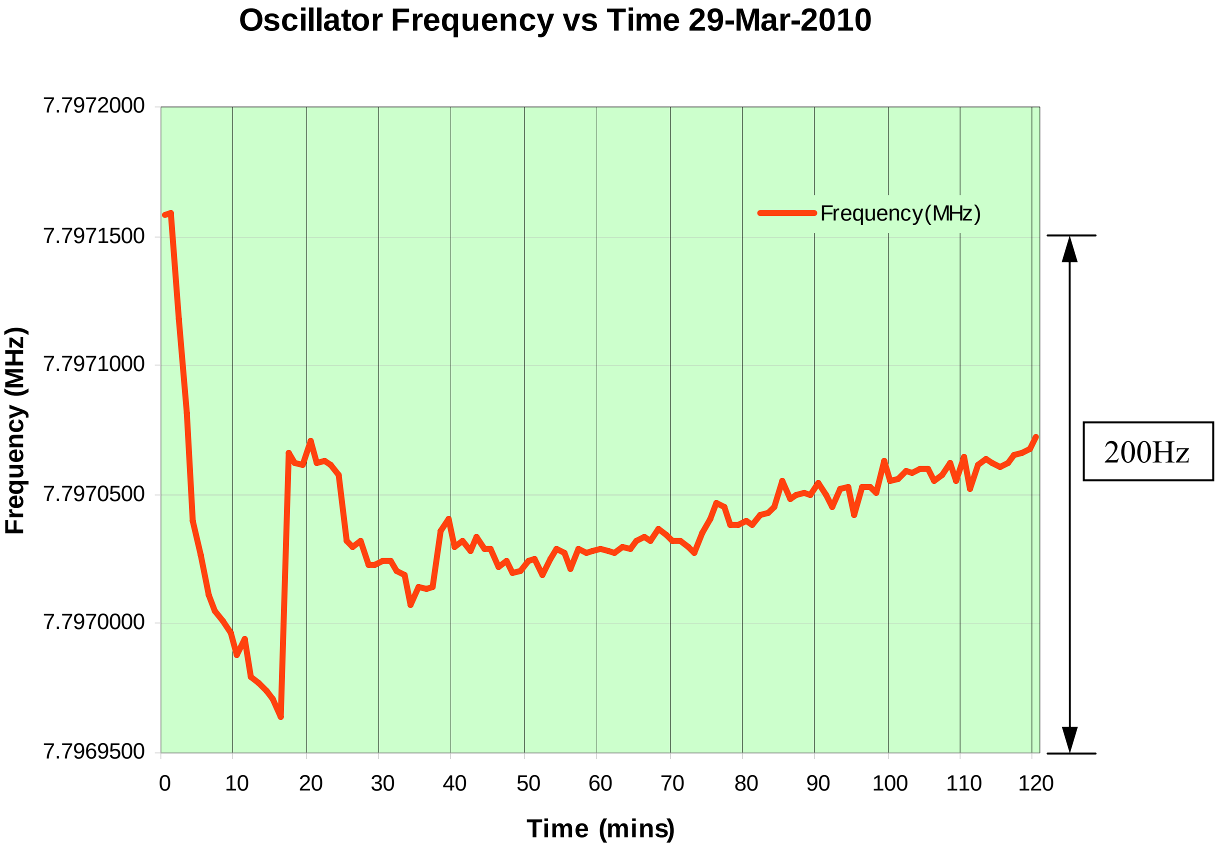
10-Apr-2010

It was found the grounding terminations for C4424 and C4425 on Z4401 was not completely soldered after careful inspection of solder terminal. The cold solder joint was repaired and the oscillator module stability was investigated again. This time with oscillator module removed and variable capacitor replaced with a 68p NPO capacitor. Module was powered by regulated power supply on both filament and plate power. Make shift connector pins for bench test came from disassembly of a DB-25 female connector.



Oscillator Stability 22-Feb-2010



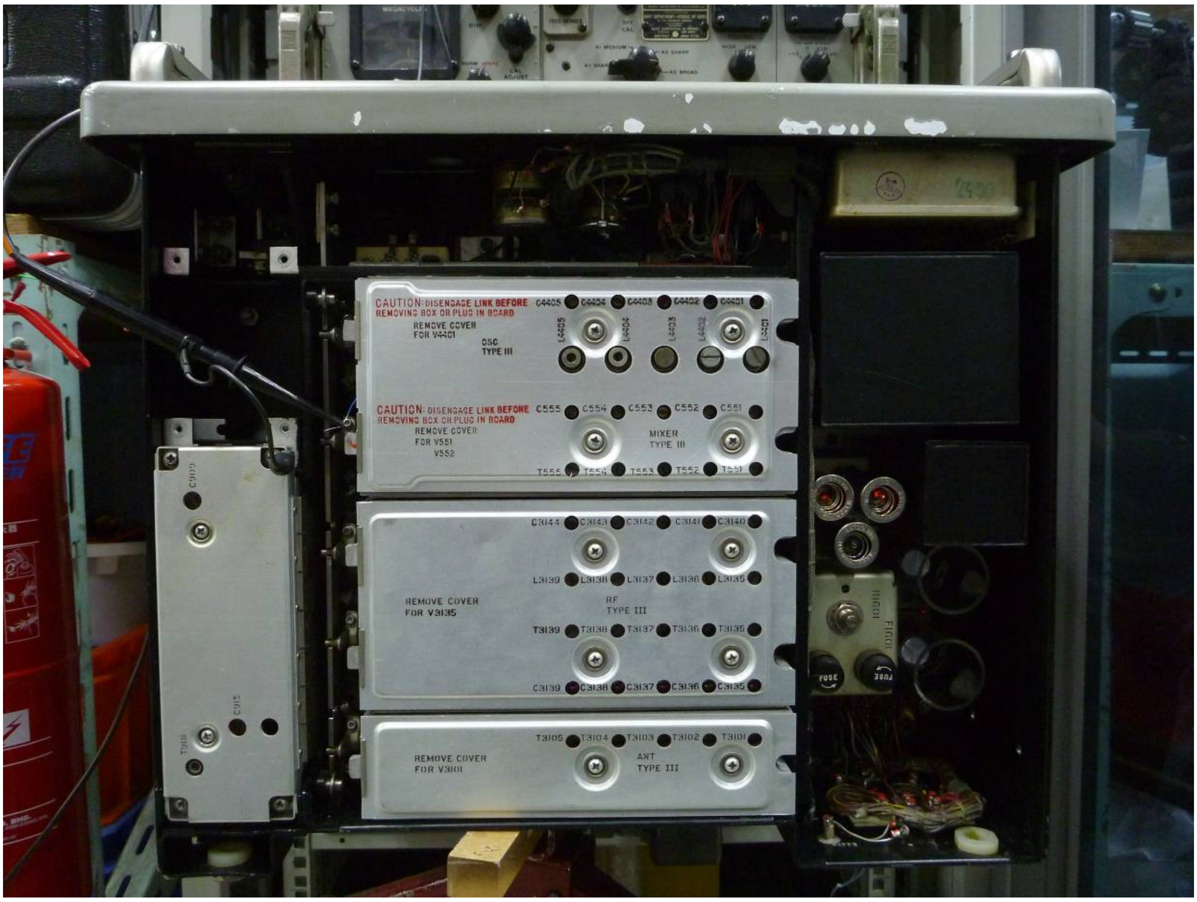


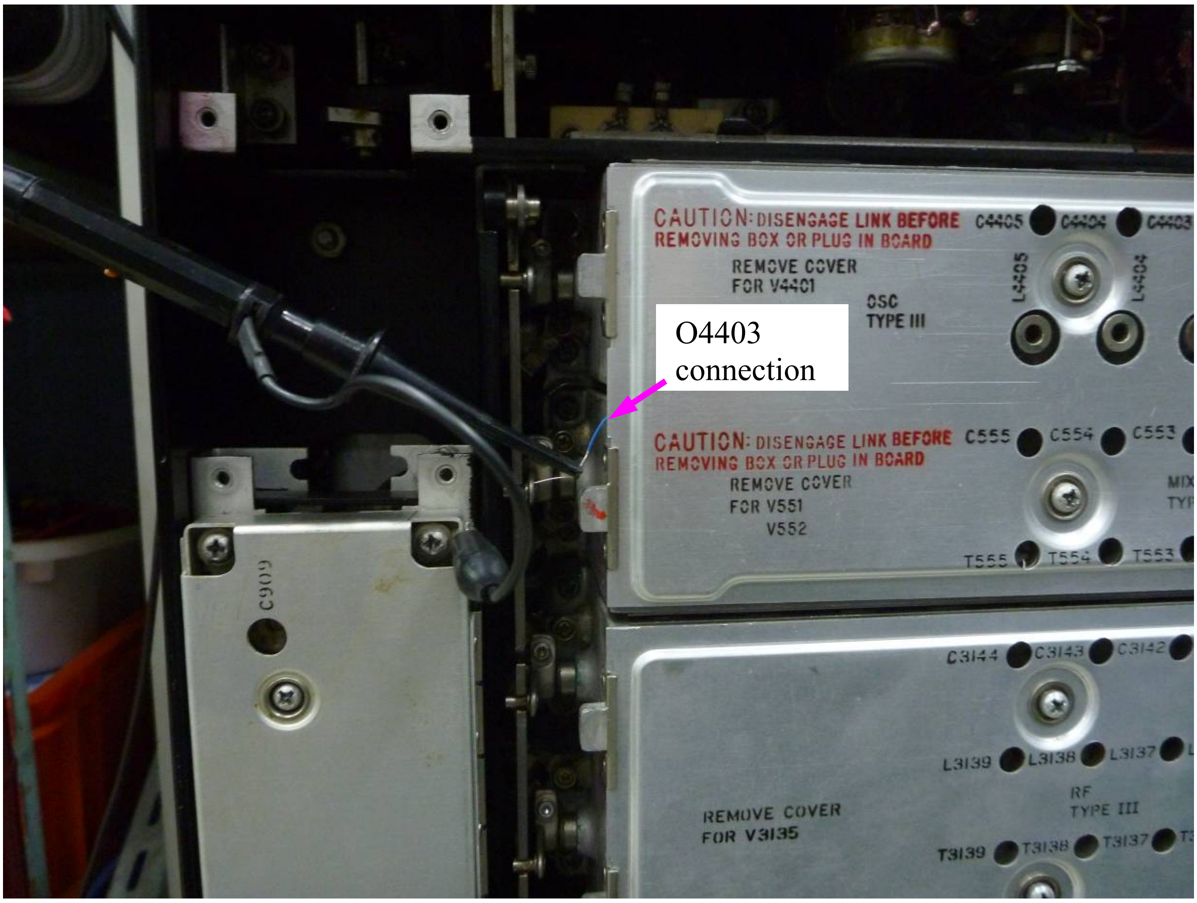
Oscillator Frequency vs Time 29-Mar-2010

Curve taken on 22-Feb was less accurate; frequency counter OCXO warm-up time was overlooked. Curve taken on 29-Mar was measured with a frequency counter verified with Rubidium standard. This conclude the oscillator module when operating alone, was reasonably stable.

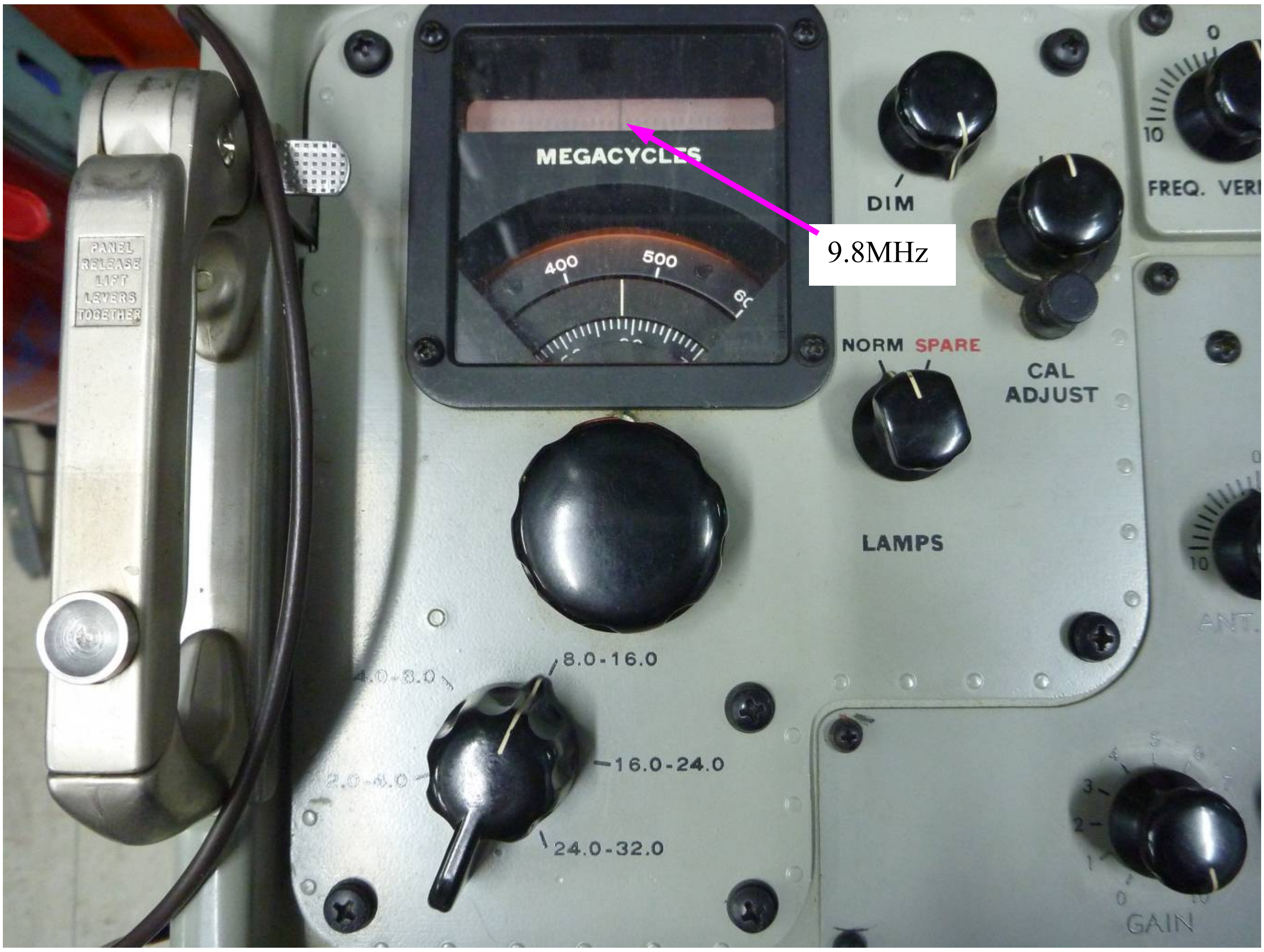
Mixer module Gate and Cathode bias resistors were checked with at elevated temperature and verified healthy. Stand-alone frequency measurement indicated good stability.

Oscillator was re-installed onto AN/FRR-23 unit and recheck for stability.

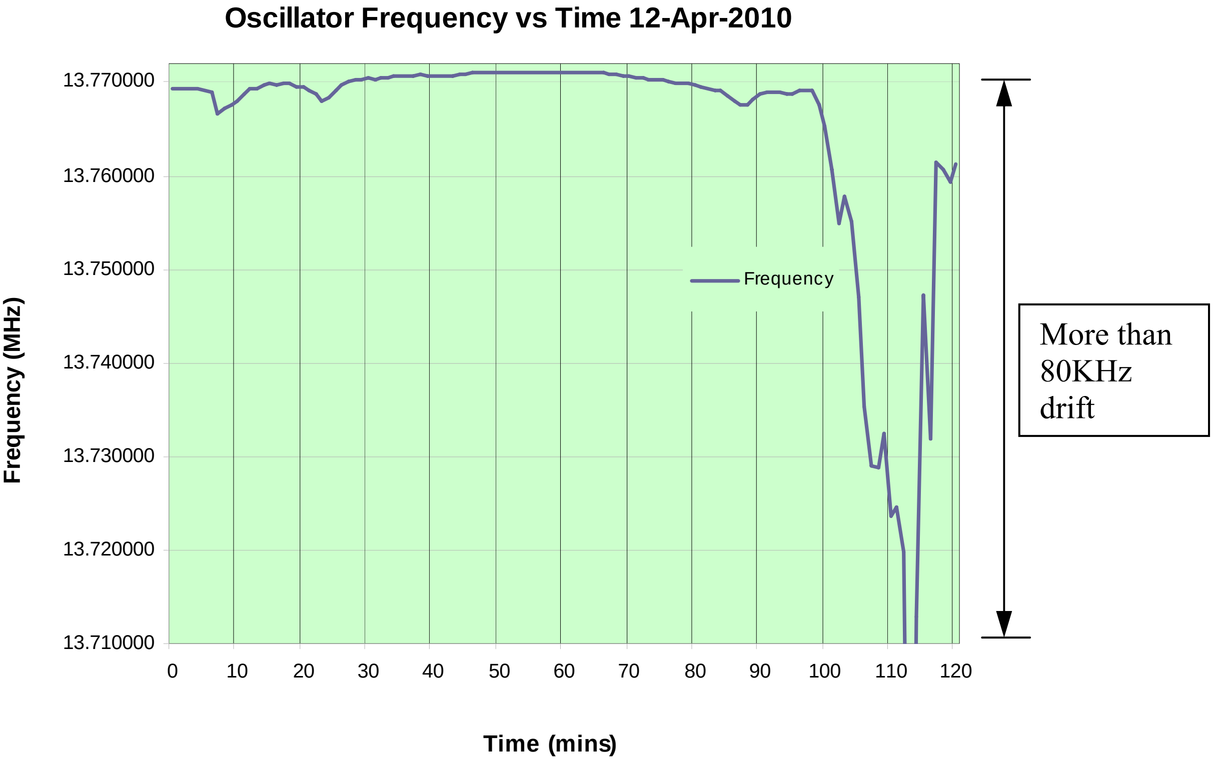




O4403 connection



9.8MHz

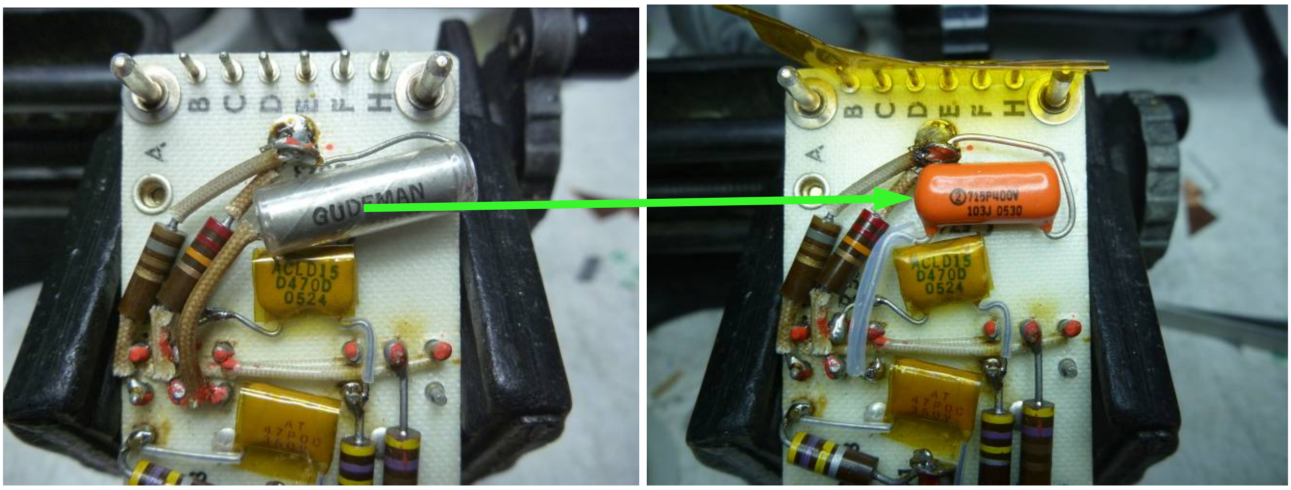


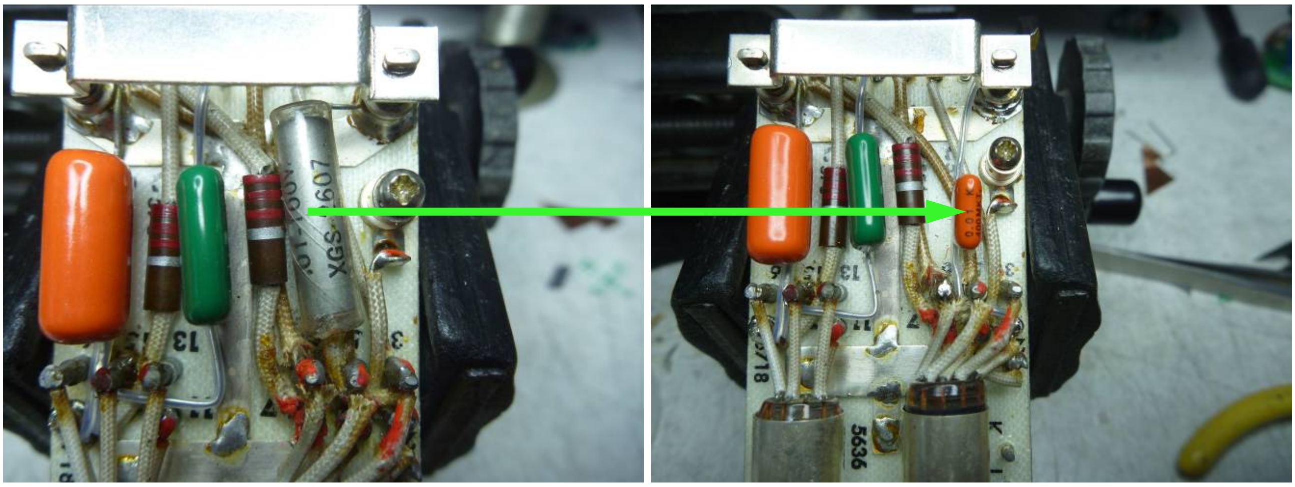
More than 80KHz drift

Stability did not improve, after nearly two hours warm-up, frequency suddenly changed more than 70KHz.

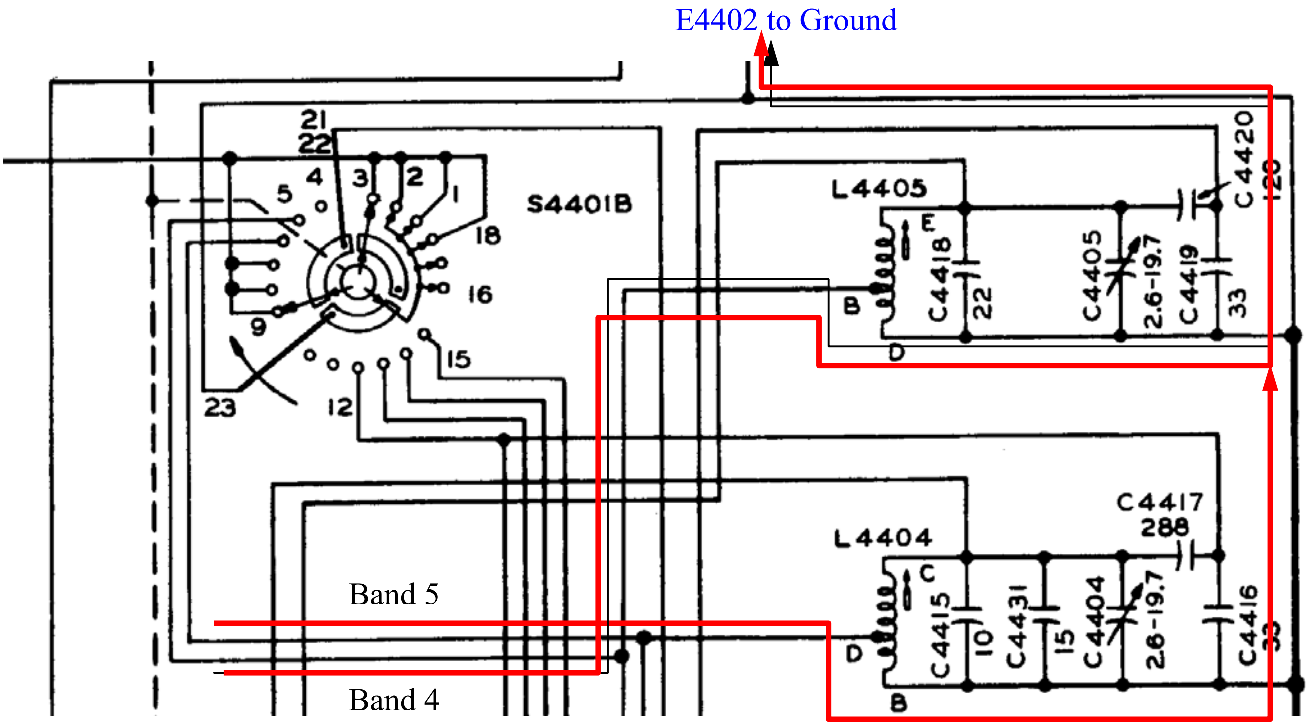
During bench test of oscillator module, module stopped operating when band switch was set to 16-24 and 24-32MHz band (band 4 and 5). Band switch wiring was traced and found the schematic of oscillator module of this unit (serial number 80) corresponds to schematic in document IB-39588-a instead of the original AN/FRR manual. Filament power return circuit is connected to V4401 Cathode to reduce audio hum at band 4/5. This particular observation led to the discovery of frequency instability root cause.

Since it was found during oscillator stand-alone test that load capacitance has significant effect on frequency, C572 and 576 on mixer module were replaced to eliminate this capacitance factor.





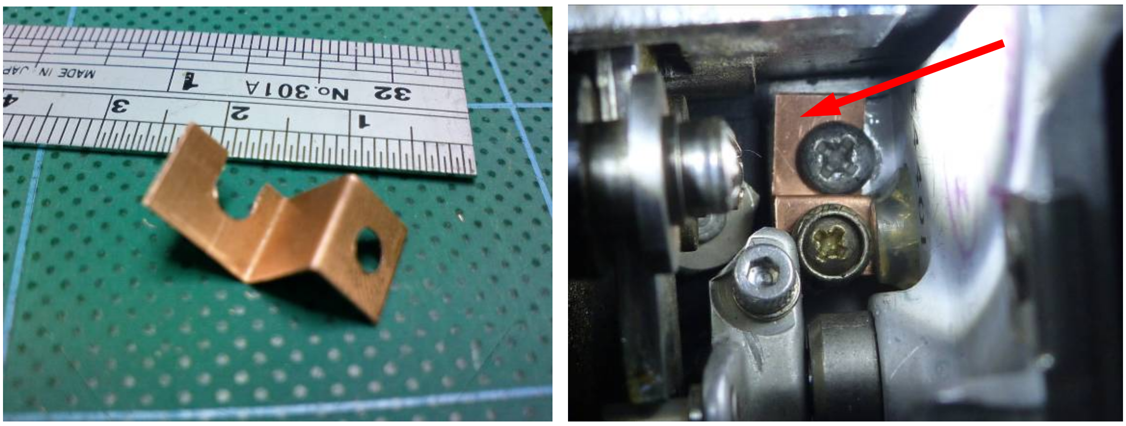
No connection mistake or band switch contact failure was found. It took some time to understand method of completing filament return power.



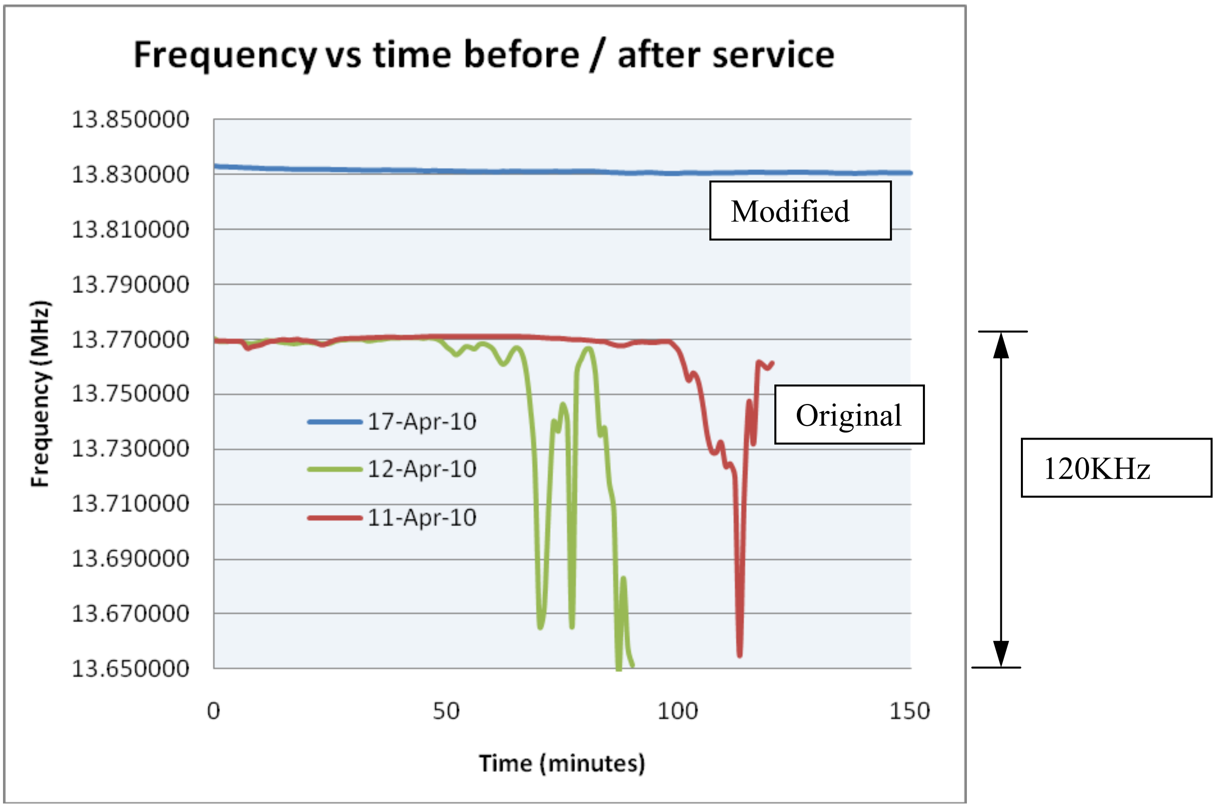
One of the filament terminal of V4401 is distributed by switch S4401B positions 5,6,7,8,9. Under band IV and V the return power is routed tap of L4404 and L4405, which is also Cathode of V4401, and eventually return to system ground via variable capacitor terminal E4402. As documented in AN/FRR manual this is to reduce AC hum at high frequency bands Band IV and V oscillates normally when E4402 is connected to oscillator module chassis.

Resistance measurement was performed on variable capacitor C2201A and other gangs and found one of the terminal has an internal connection to the metals casing. Good resistance reading should be lower than 1Ω. Resistance between C2201A and casing was found to be unstable. The resistance varied together with tuning dial setting and can change with mechanical tapping of the capacitor assembly casing. Resistance as high as more than 50Ω was measured at dial setting between 400-600, and can be restored to a reasonably low value when the casing or FRR chassis was tapped. This explained why the oscillator has a rare intermittent operation problem at band IV and V when resistance was high enough to reduce filament current to a level that stopped V4401 normal operation. This contact resistance problem was identified as the root cause of frequency instability. Resistance affected oscillator frequency as well as oscillator output amplitude, frequency and amplitude dropped as resistance increased.

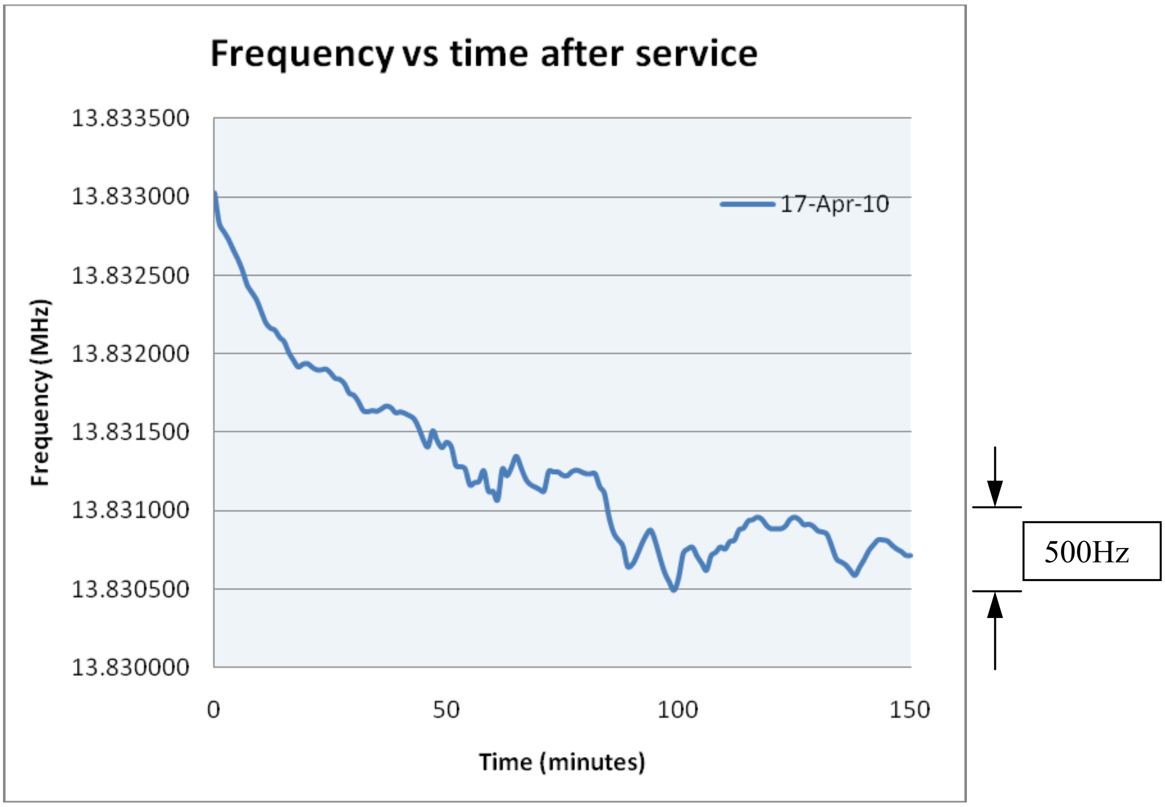
The internal construction of the variable capacitor assembly is not clearly understood without dis-assembly of the capacitor unit casing. An attempt to bypass this contact problem, assuming the rotor plate to case connection is still intact. A ground strap was constructed with 0.2mm thick Copper foil and installed between E4402 and neighboring module mounting screw. Allowing completion of capacitor ground circuit via casing instead of E4402. There is a worry of allowing high frequency oscillator current passing thru capacitor casing thru chassis and interfering with RF stages. This is a secondary consideration at the moment.



Oscillator stability was checked again after addition of ground strap.

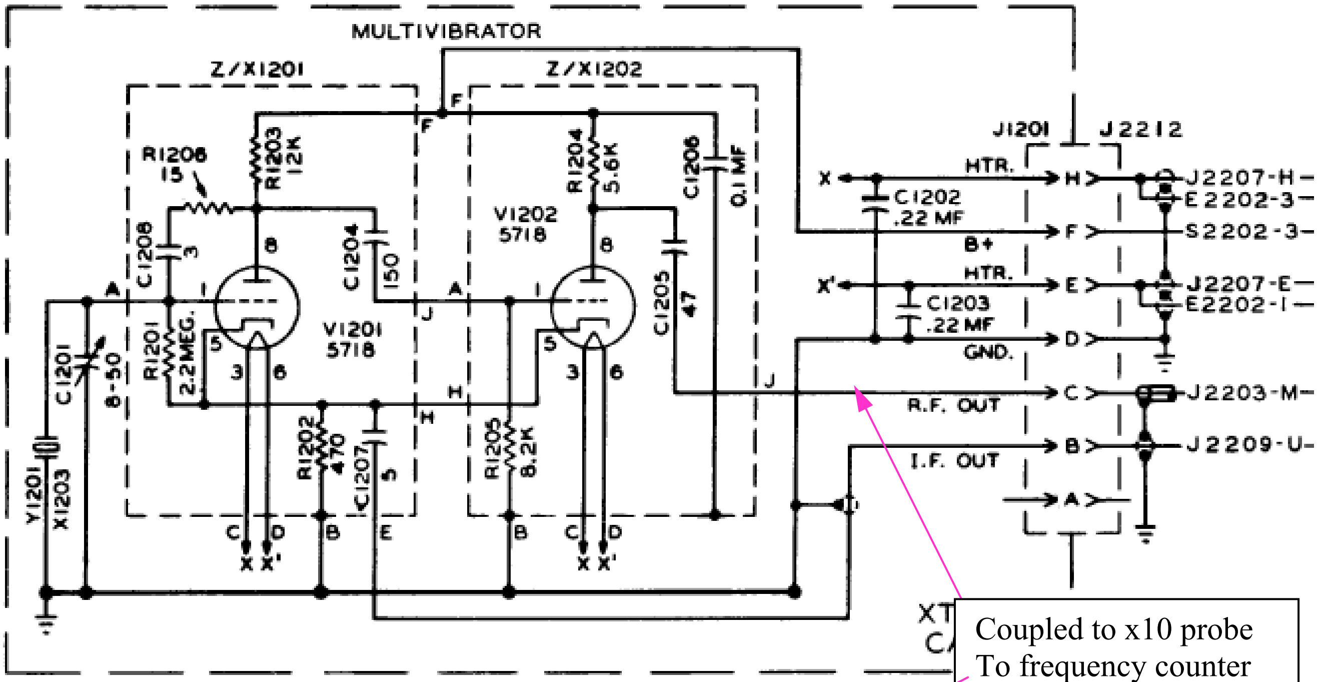


The whole test lasted 150 minutes, the abrupt drift in oscillator frequency was no longer observed.

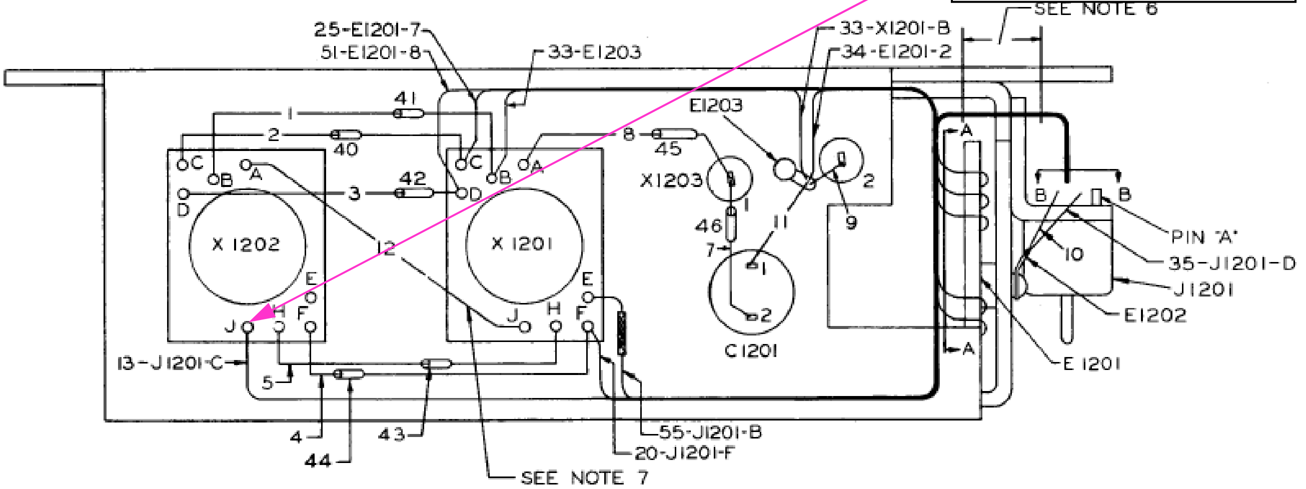


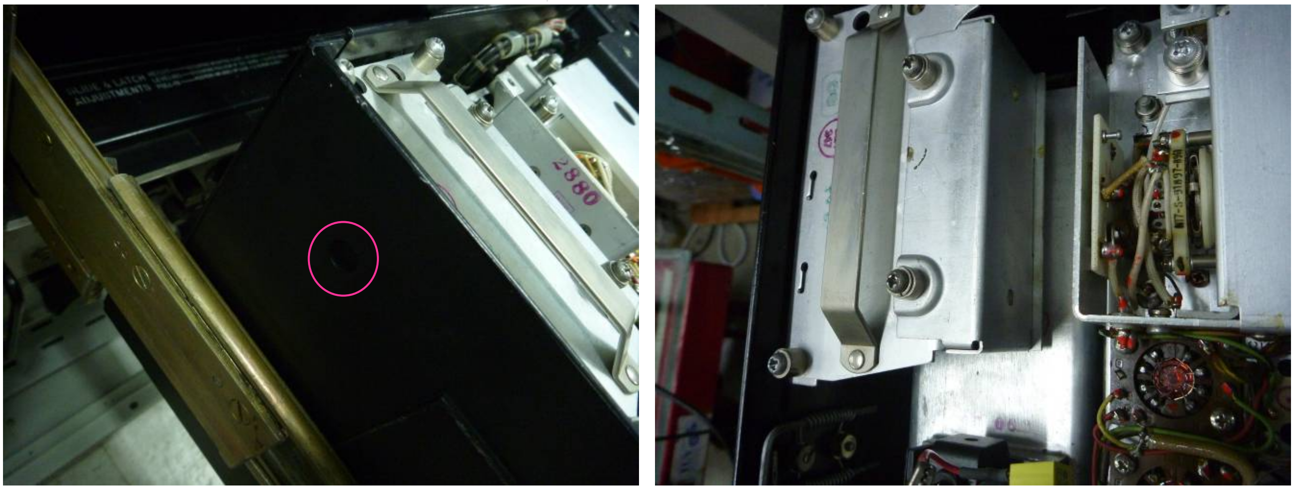
Receiver appeared less sensitive as before. Frequency accuracy was checked with a signal generator and found to be off towards the low end by approx 60KHz. Re-alignment is necessary.

22-Apr-2010 Calibration oscillator adjustment, Manual page 7-68, PDF page 143



Coupled to x10 probe
To frequency counter
Via a 2.2p capacitor



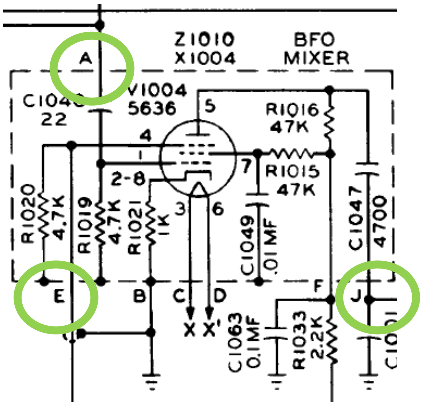


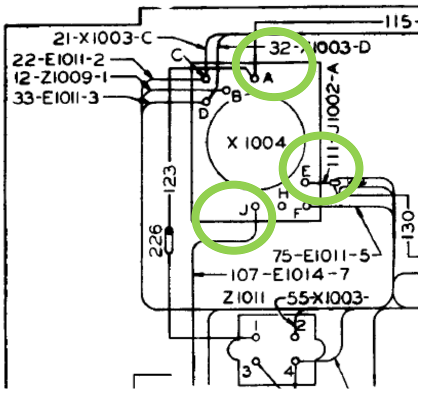
Calibrator housing heated up to 55ºC using DC powered resistor. Frequency re-adjusted to 199.99917KHz after 3 hours warmup. Temperature coefficient is quite high by today's standard. Cold frequancy drifted +10Hz at startup. Every one Hertz deviation at 200KHz represents a 10Hz calibration marker frequency shift at 2MHz and 160Hz at 32MHz.

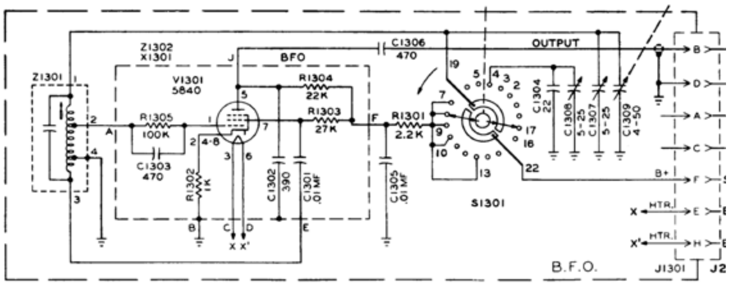
C1201 is accessed thru a chassis hole located on the left hand side of calibrator oscillator.

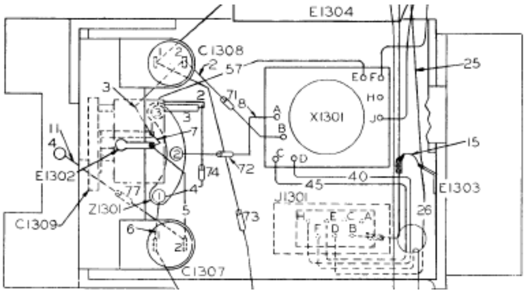
A straight wide blade screwdriver protected with soft material at the tip(insulation tape is good). This is to prevent damage to the trimmer capacitor ceramic body by metal screwdriver blade.

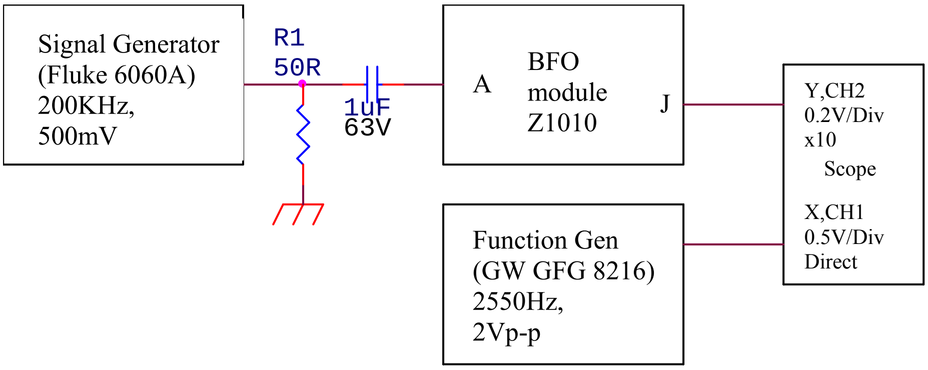
24-Apr-2010 BFO alignment, Manual page 7-64, PDF page 138

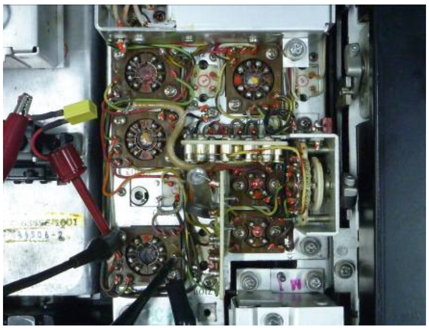












Note:

- Considering the questionable availability of frequency counter when this equipment was developed. This alignment design was based on zero beat rather than actual measurement of oscillator frequency. In fact frequency can be measured using frequency counter measuring input “E” of BFO module. Frequency drift caused by probe loading is within 15Hz.

- Signal generator output is loaded with 50Ω, to allow DC path for 1uF coupling capacitor.

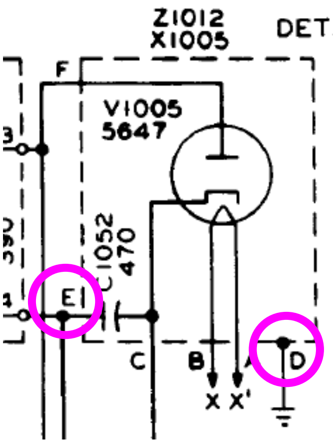
- The “zero beat” is better detected by monitoring audio output waveform than listening. Step (d) (6) the “circular pattern” is actually a 3-D cylinder like pattern due to presence of 200KHz carrier at mixer output.

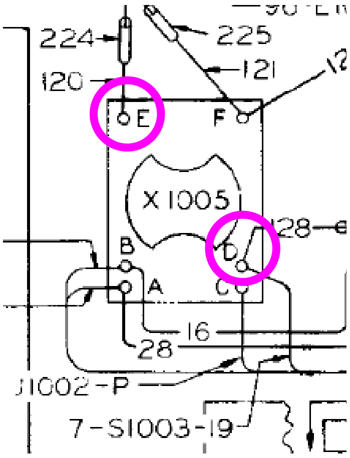
- Check mechanical position of BFO variable capacitor moving vane when BFO knof is at zero position before alignment. Make adjustment if necessary.

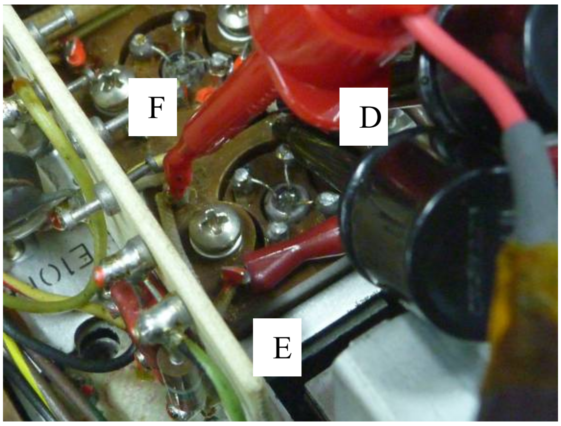
- Use proper tool or protection to prevent trimmer capacitor from chipping

24-Apr-2010, IF alignment, manual page 7-62, PDF page 136

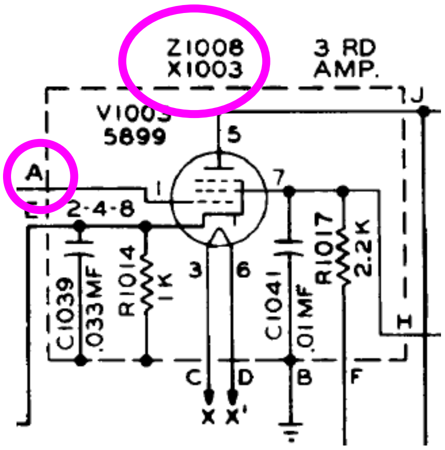
- Reception to A2 (A1 medium), DC voltmeter (Fluke 17B DMM), Z1012- E to Ground (Z1012 D), note Z1012-E is negative, keep voltage reading at 0-10V, prevent coil insulation breakdown.
- No **A2 Reception** on FRR-23, use **A3 Broad** instead, signal generator level 300mV

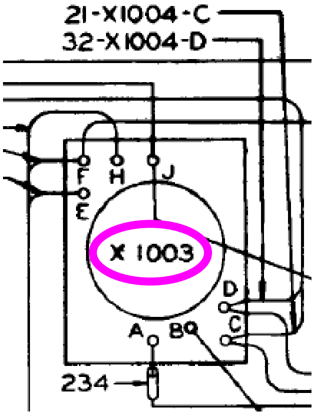


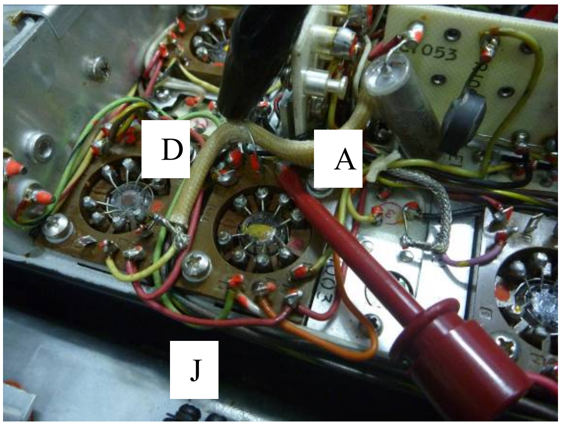




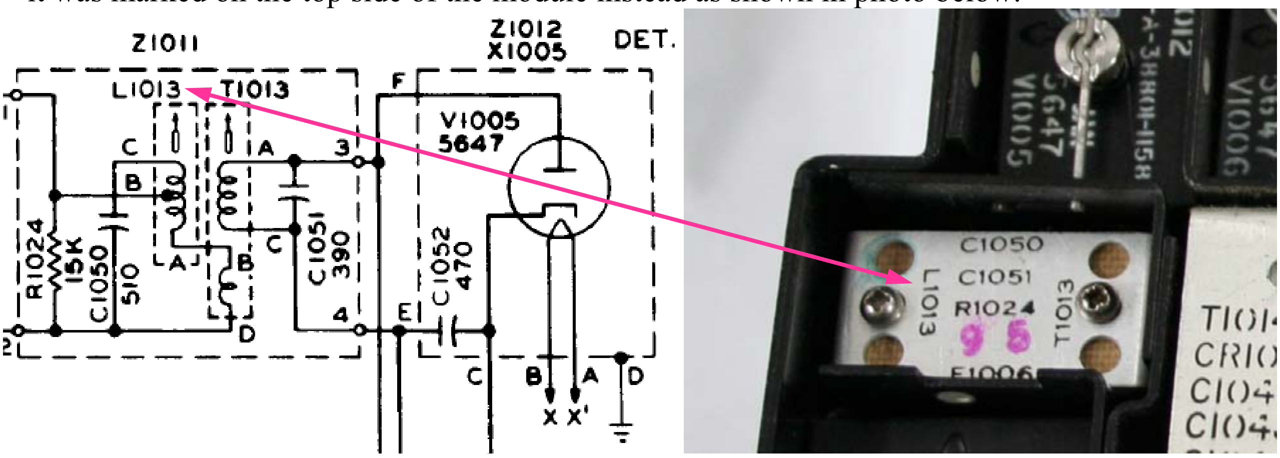
- Signal generator frequency 200KHz, 50Ω loaded, connects signal generator output to Z1008-A via a 1uF capacitor.
- Adjust generator signal level (300mV) to maintain 0-10V (5V) on voltmeter.







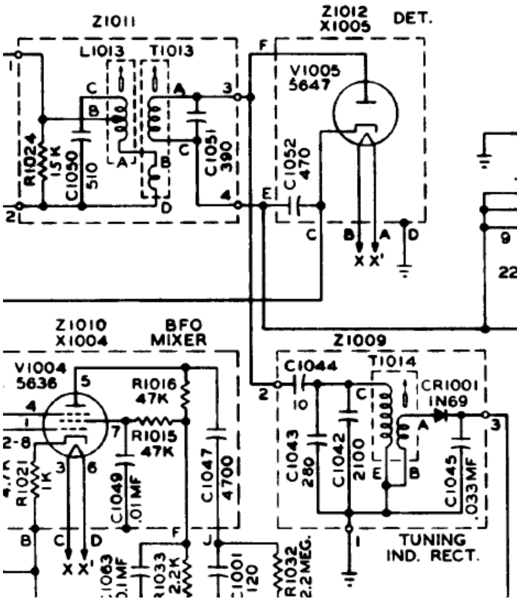
- Connect a shunting capacitor of 680pF across Z1012 F (where X1005) to Ground.
- Tune L1013 for maximum output, on unit S/N:80 L1013 max at full out position, -0.766V.
- Note L1013 and T1013 was neither indicated in FRR-23 manual nor on the socket side of IF module, it was marked on the top side of the module instead as shown in photo below.



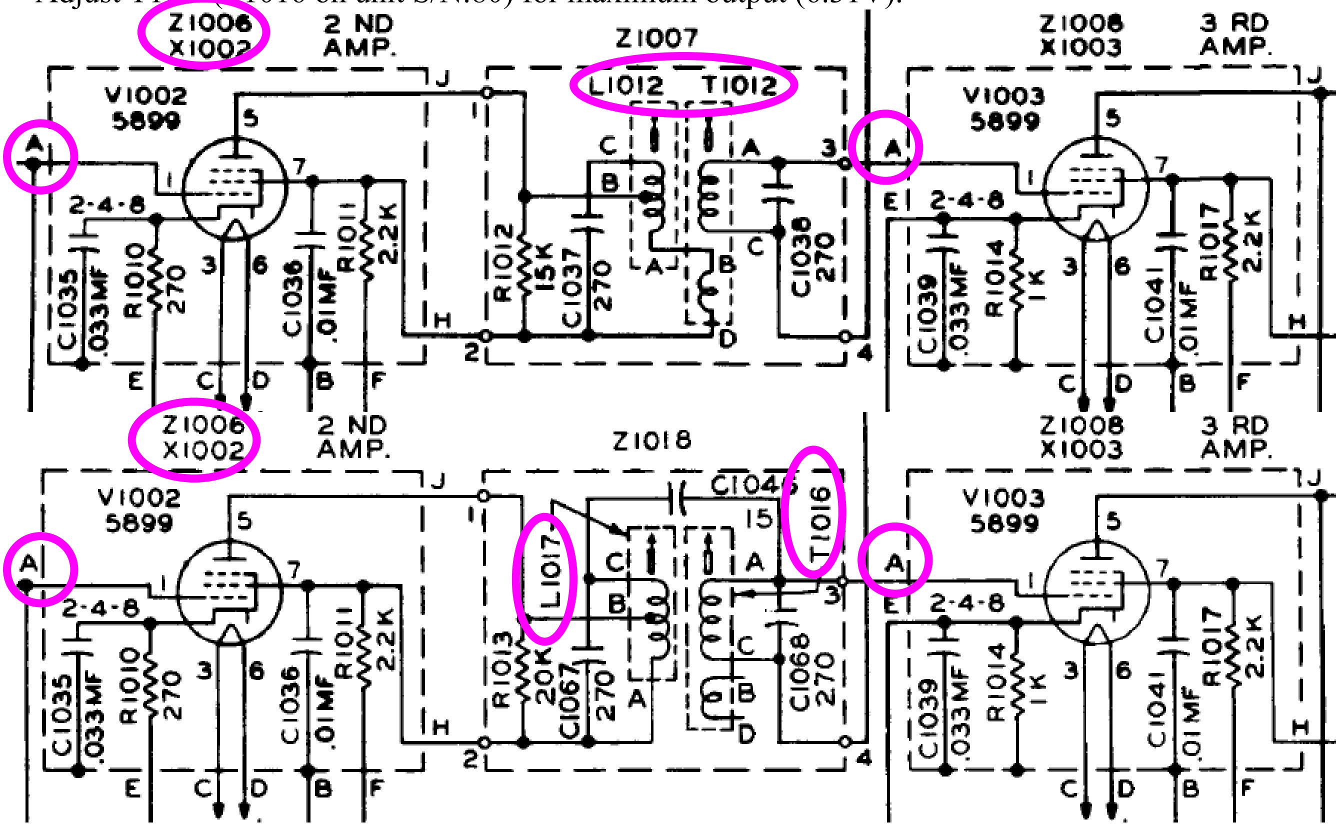
- Remove shunting capacitor at Z1012 F, adjust T1013 for maximum detector output (5.82V).

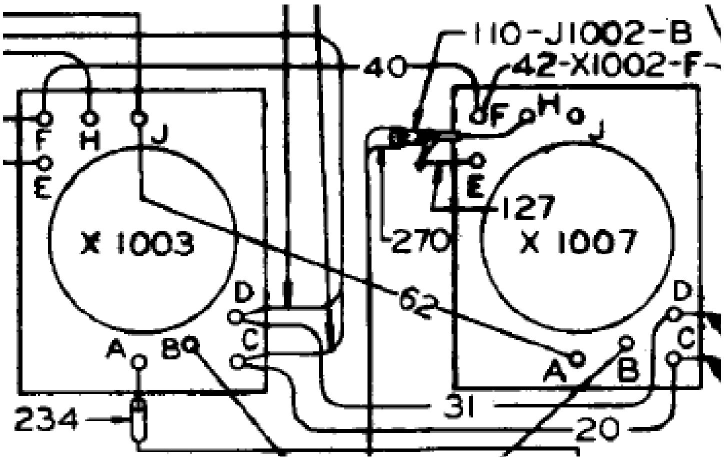
Tuning Rectifier alignment

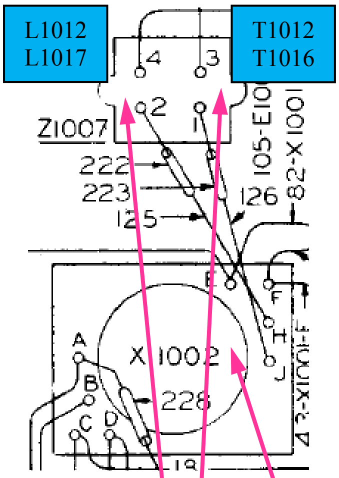
- Maintain signal generator connection to Z1008-A
- Disconnect shunt capacitor at Z1012-F to ground.
- Monitor voltage level at Z1009-3 with a voltmeter.
- Adjust T1014 for maximum output.
- Check adjustment of L1013 and T1013 again, re-adjust if necessary.

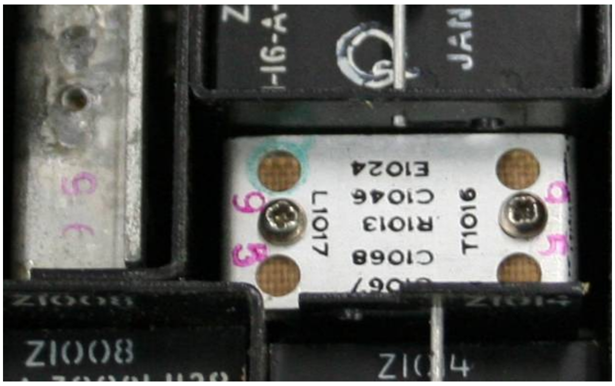


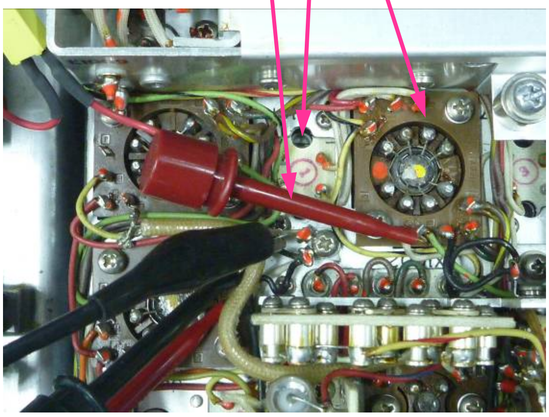
- move signal generator output from Z1008-A to Z1006-A (i.e. to the next amplifier stage in front).
- Connect shunting capacitor between Z1008-A to Ground, signal generator output 50mV
- Adjust L1012 (L1017 on unit S/N:80) for maximum detector output (-1.742V).
- Remove shunt capacitor from Z1008-A to ground, signal generator output 10mV.
- Adjust T1012(T1016 on unit S/N:80) for maximum output (6.31V).



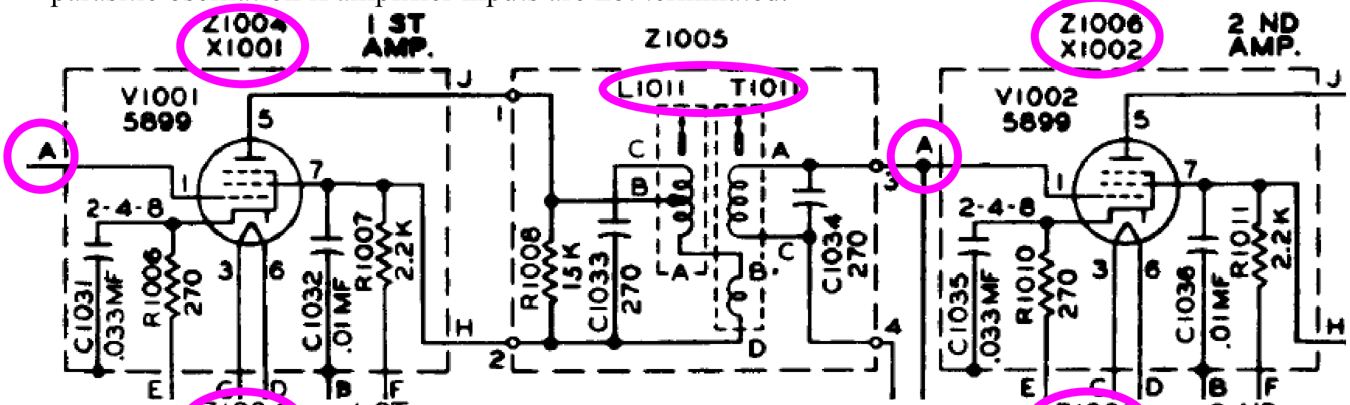


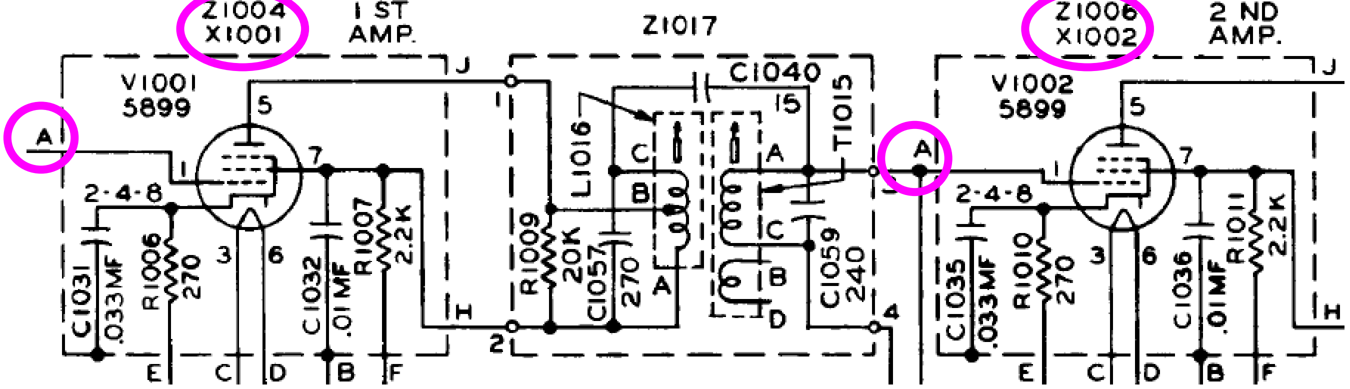


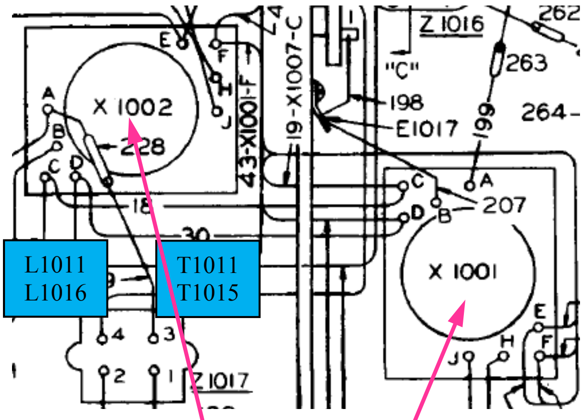


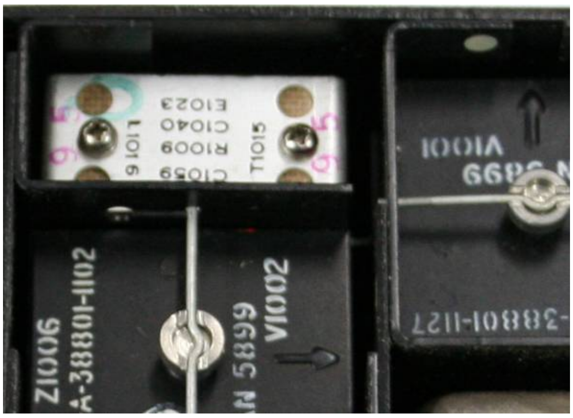


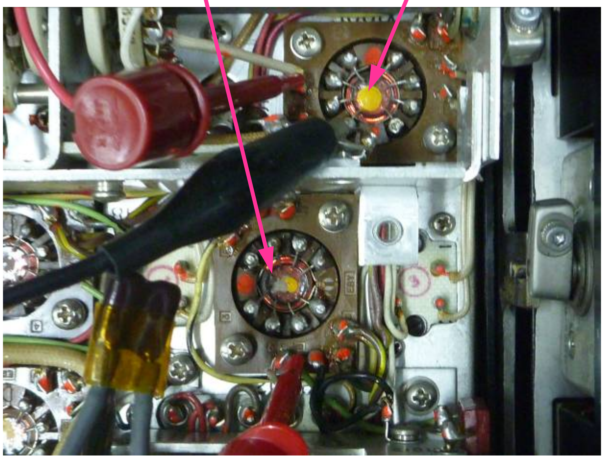
- Move signal generator output to Z1004-A, connect shunt capacitor to Z1006-A.
- Signal generator output (3mV), Adjust L1011(L1016) for maximum output (6.80V)
- Remove shunting capacitor at Z1006-A
- Signal generator output (60uV) adjust T1011(T1015) for maximum output (4.80V)
- *** Accessing Z1004 requires metal cover removal of section Z1004 and band switch resulted in parasitic oscillation if amplifier inputs are not terminated.



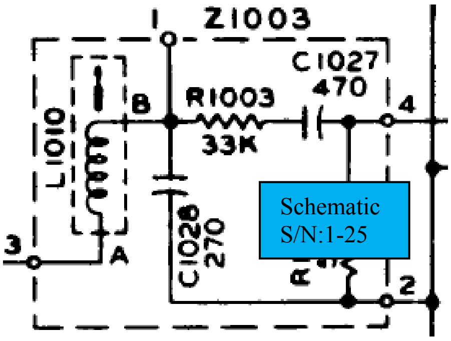




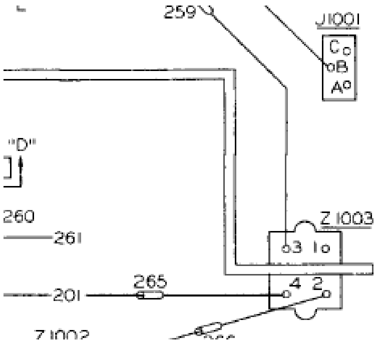


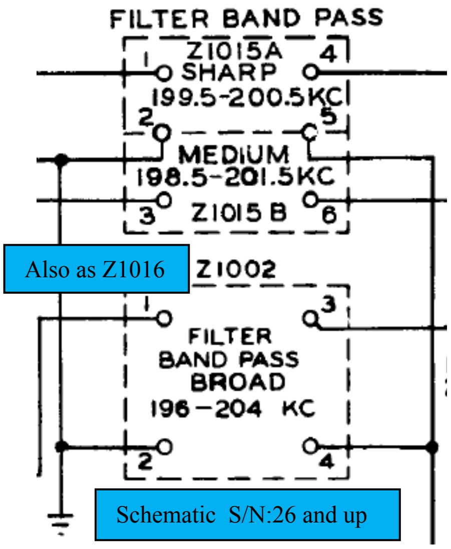


- Connect shunting capacitor to Z1003-1 to Ground. Skip this for unit S/N 26 and above.
  Or alternatively connect shunting capacitor to Terminal 3-4 of Z1002/Z1016
- Signal generator connects to Z901-A, adjust T901 for maximum output, 100uV, 6.51V detector
- Remove shunting capacitor at Z1003-1.
  Or remove capacitor at terminal 3-4 of Z1002/Z1016
- ***For unit S/N: 26 and above (S/N:80), there is no Z1003-1. Also even in S/N:1-25, input signal does not pass thru Z1003 and is routed thru Z1002 with A2/A1 medium receiving setting. Therefore loading Z1003-1 does not alter signal strength.
- ***First IF module cover cannot be removed without unplugging module, re-installation can be performed with module plugged in.



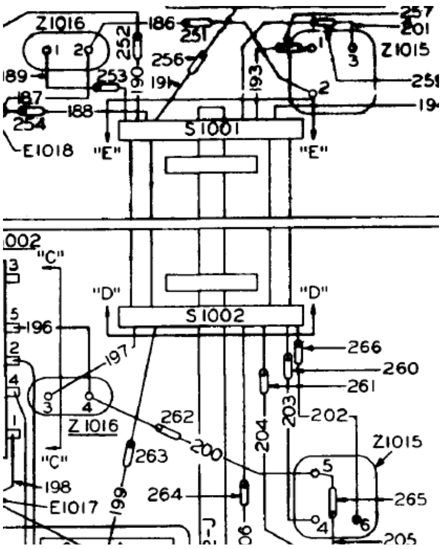
Schematic S/N:1-25

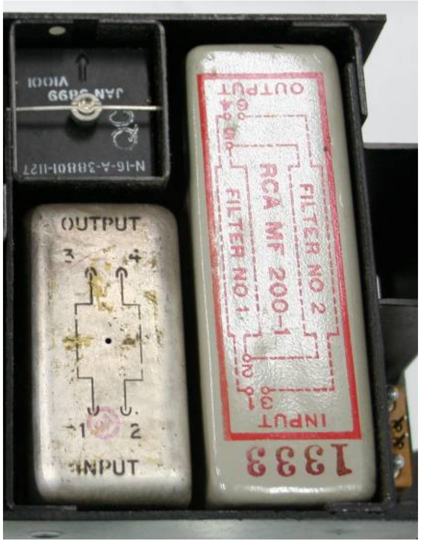


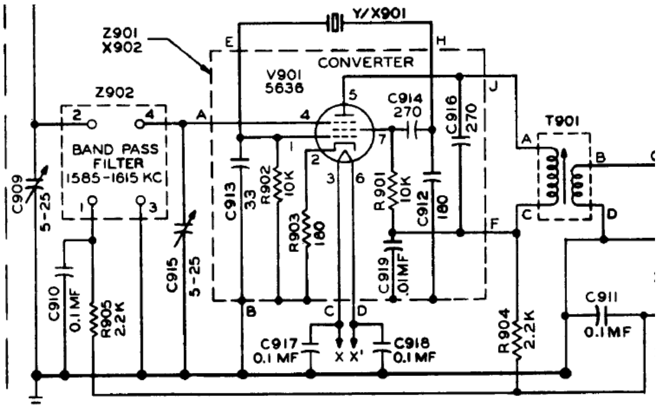


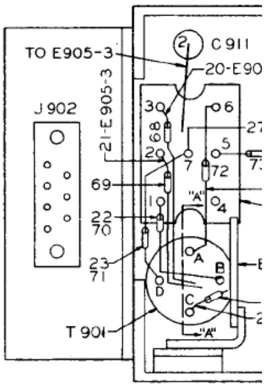
Also as Z1016

Schematic S/N:26 and up









28-Apr-2010, 2nd IF filter alignment, manual page 7-63, PDF page 137

- Connect electronic voltmeter to pin E of Z1012 and Ground.
- Connect signal generator to 1st IF stage Z901-A coupled with a 1uF capacitor. Set frequency to 200KHz.

Applicable for AN/FRR-23 serial number 1-25 only

- Set reception control to A1 sharp.
- Adjust signal generator level to maintain 0-10V voltage level on detector voltmeter.
- Adjust C1029 for maximum output indication.

No adjustment required on Broad and Sharp IF filter needed on AN/FRR-23 S/N:26 and above

-*** C1029 is not coupled to Broad and Sharp filter and is shorted via C1030 (10nF)

A3 Broad filter adjustment

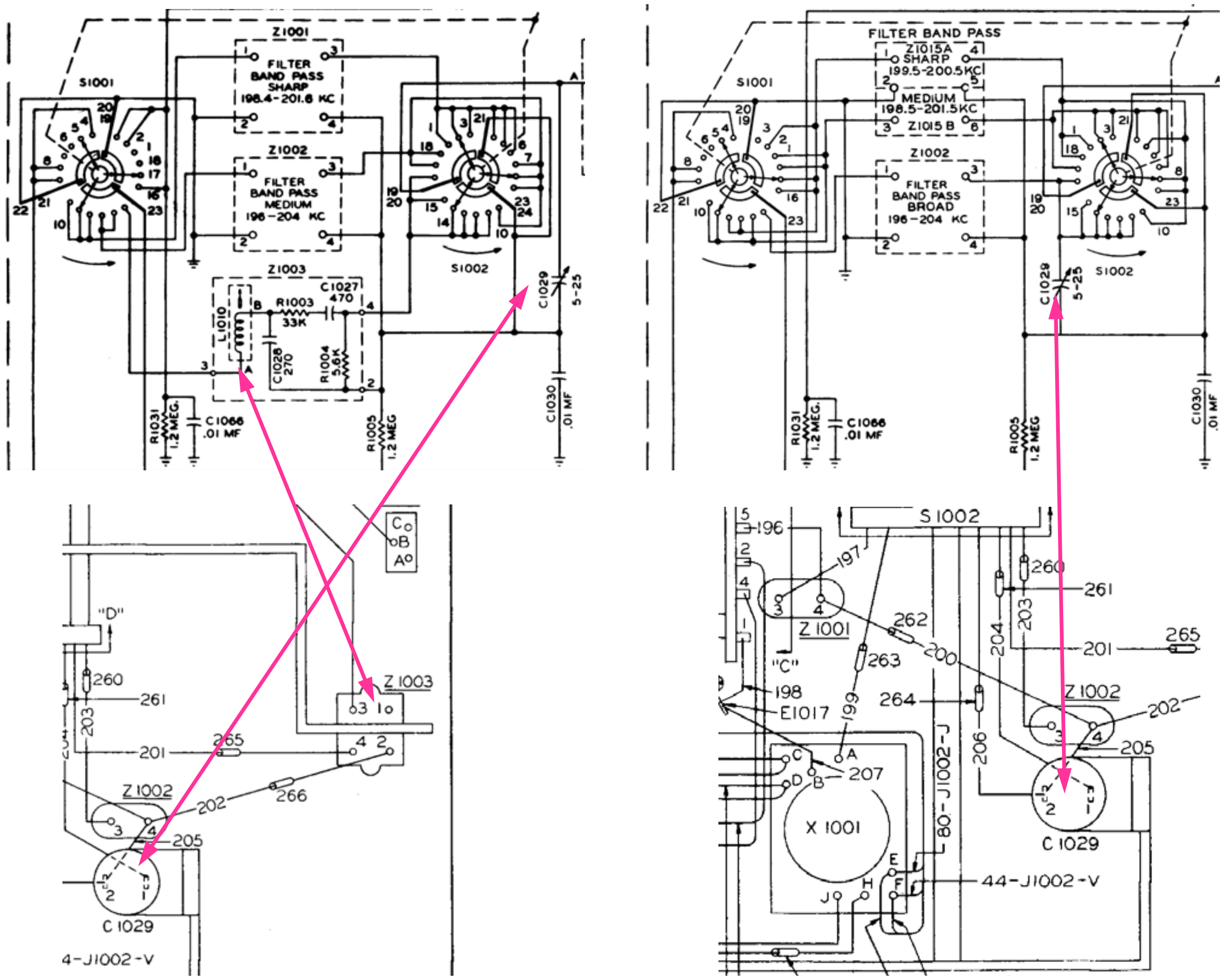
- Set Reception control to A3 Broad

Applicable for AN/FRR-23 serial number 1-25 only

- Adjust L1010 for maximum output indication on voltmeter

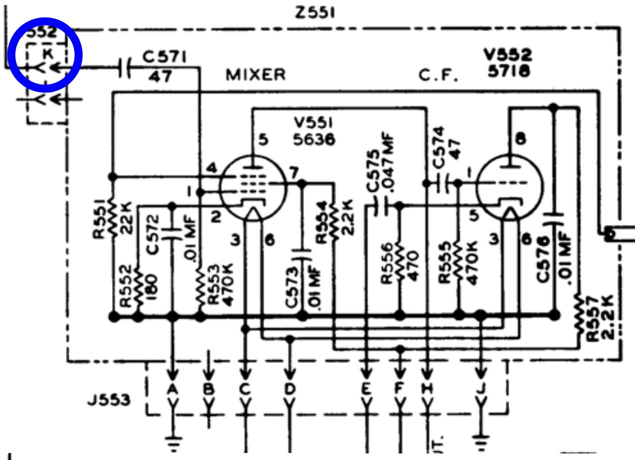
Applicable on AN/FRR-23 S/N:26 and above

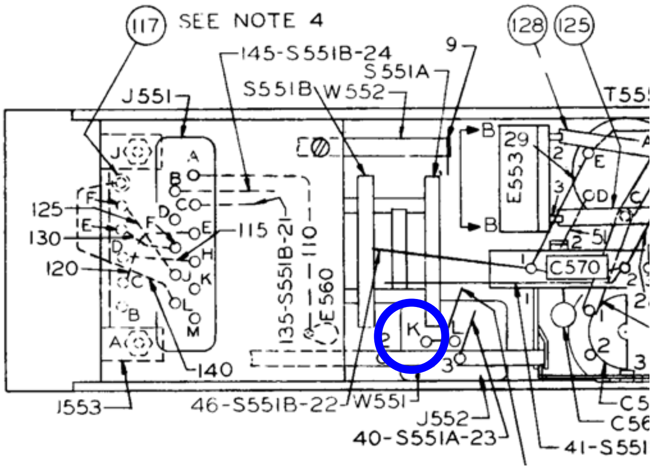
- Signal generator 150uV, detector reading 5.75V.
- Re-install metal cover before alignment of C1029.
- Adjust C1029 for maximum indication on voltmeter

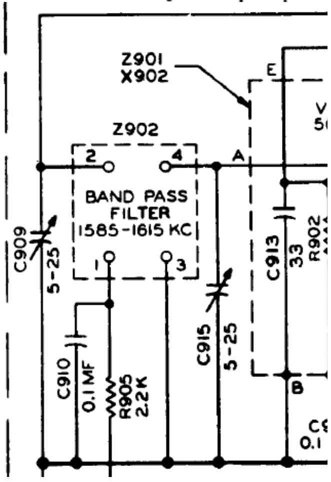


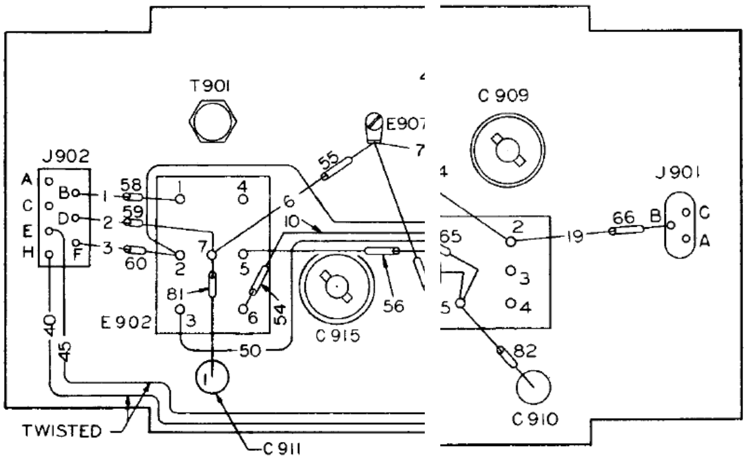
29-Apr-2010, First IF band pass filter alignment, manual page 7-64, PDF page 138

- Connect electronic voltmeter to pin E of Z1012 and Ground.
- band switch to Band IV, reception A3 Broad.
- Signal generator to RF mixer stage, J552-K, via 1uF+51Ω.
- Signal generator frequency to 1600KHz
- Re-install metal cover on 1st IF module before alignment.
- Adjust C909,C915 on 1st IF module for maximum reading on detector voltmeter, 2mV, -4.50V









30-Apr-2010, RF alignment Local Oscillator, manual page 7-68, PDF page 142

- Connect signal generator to Antenna input using MX-1074 impedance adapter and SM-35 Antenna Simulator.
- Use RF alignment procedure (b) *alternate method* reason being difficulty to jumper position 2,3 of Calibrator switch when unit is in vertical position.
- Set receiving mode to A1 Broad.
- Switch Calibrator switch ON (Calibrator power on, BFO power off, RF amp power off), move tuning dial away from a calibrator marker frequency (i.e. avoid a marker frequency harmonic).
- Increase signal generator signal strength (10mV in our case), RF signal leaked into mixer will generate a side band at IF output. Adjust signal generator frequency to generate a beat note and further adjust signal generator frequency to obtain zero beat.
- Switch Calibrator OFF (Calibrator power off, BFO power on, RF amp power on), adjust BFO frequency to obtain zero beat. After this step the BFO is at the correct 2nd IF frequency of 200KHz. Accuracy of subsequent local oscillator alignment steps will therefore dependent on the stability of the BFO frequency. It is best to repeat BFO frequency adjustment at every band to ensure good result.
- When this is complete the local oscillator frequency is at the desired frequency that will mix with input frequency to generate correct IF signal. (found local oscillator was 33KHz off tuning dial at 8MHz on the first trial).

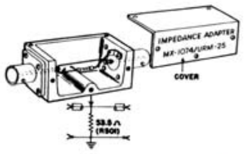


Figure 2-10. Impedance Adapter MX-1074/URM-25

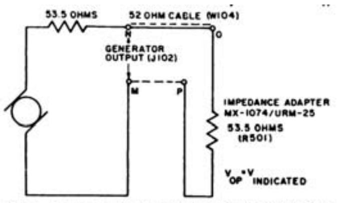


Figure 2-11. Equivalent Circuit of X MULT RF OUTPUT (J-102) with Impedance Adopter MX-1074/URM-25 Added

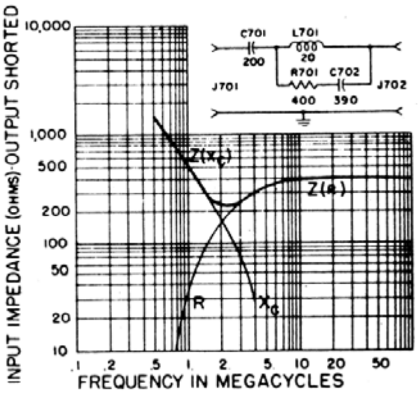
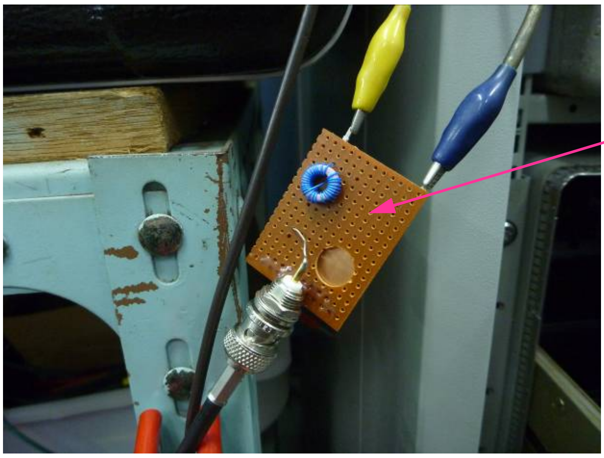
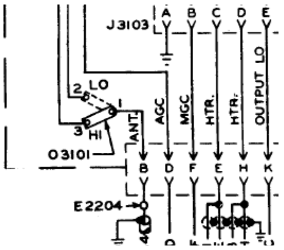


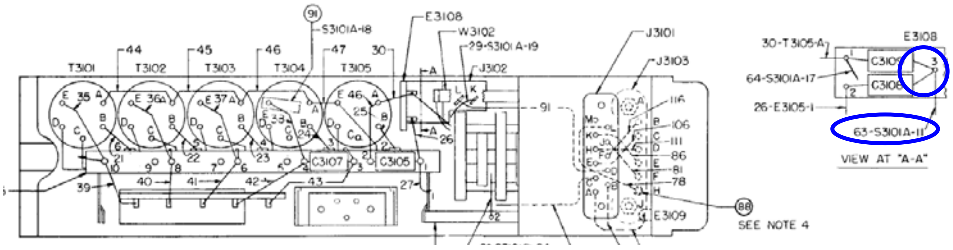
Figure 4-8. Schematic Diagram of the Antenna Simulator SM-35/URM-25 with Input Impedance Frequency Curve

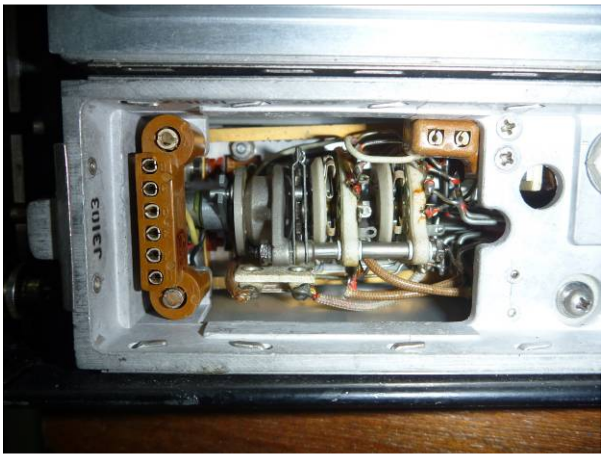


PCB with 51Ω termination resistor and antenna simulator circuit combined.

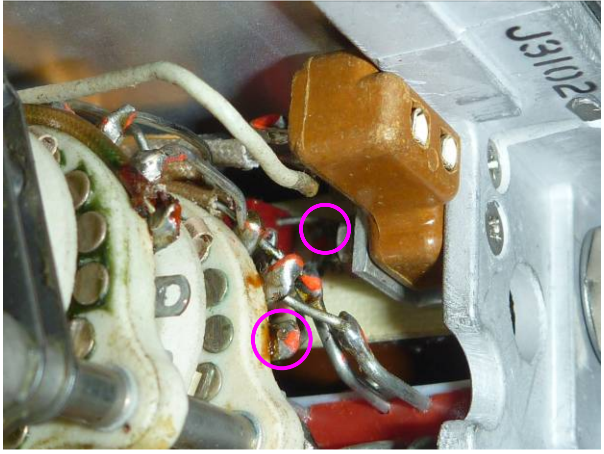
- Set link O3101 of AN/FRR-23 receiver to a position so as not to connect to any of the terminals. Connect a 39pF capacitor to terminal 10 of Z101, terminal 3 of E3008 or terminal 3 of E3108 (note Z101 is on FRR-21 schematic, E3008 is on FRR-22 antenna assembly drawing, E3108 is on FRR-23 antenna assembly drawing) and ground.







- Apply signal generator output directly to the same terminal that the 39pF capacitor was connected in above step. This will need to be done with Z3101 unplugged.



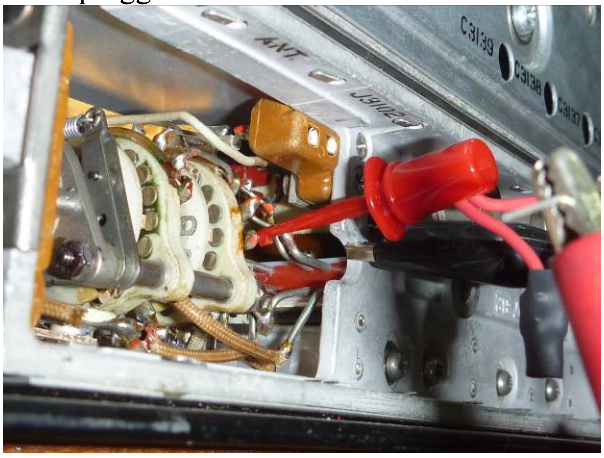
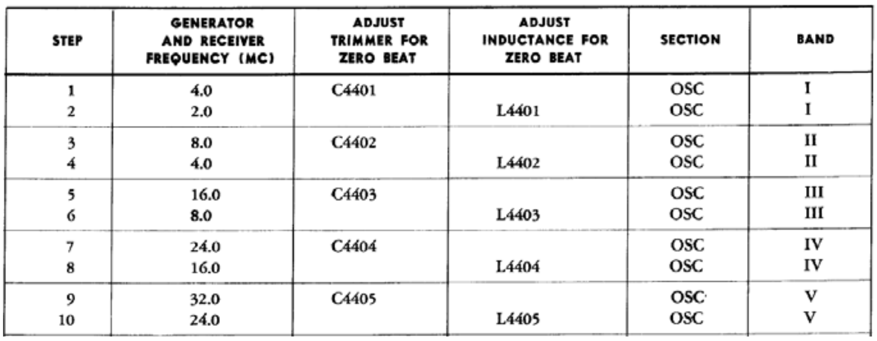


TABLE 7-10. R-F ALIGNMENT PROCEDURE, AN/FRR-23



STEP	GENERATOR AND RECEIVER FREQUENCY (MC)	ADJUST TRIMMER FOR ZERO BEAT	ADJUST INDUCTANCE FOR ZERO BEAT	SECTION	BAND
1	4.0	C4401		OSC	I
2	2.0		L4401	OSC	I
3	8.0	C4402		OSC	II
4	4.0		L4402	OSC	II
5	16.0	C4403		OSC	III
6	8.0		L4403	OSC	III
7	24.0	C4404		OSC	IV
8	16.0		L4404	OSC	IV
9	32.0	C4405		OSC	V
10	24.0		L4405	OSC	V

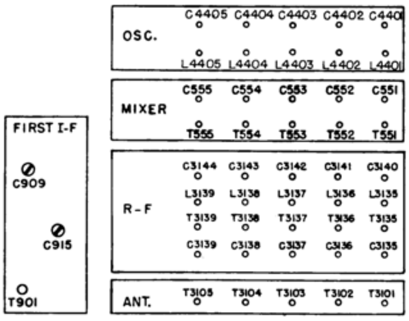


Figure 7–17. R-F Alignment Points, AN/FRR-23

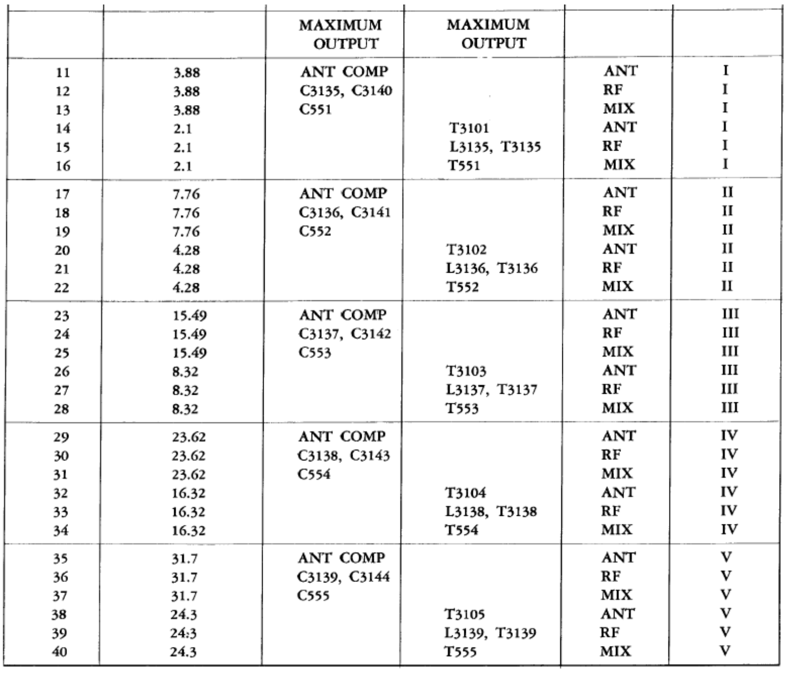
- Perform oscillator alignment according to table 7-10 above, coil positions as in figure 7-17 above.
- Band I, II and III has metal coil caps that need to be removed before alignment. There is a rubber seal inside each coil cap. The seal could remain at the coil cylinder when cap is removed and sometime it looks like the coil is sealed with black wax. A gentle poke will reveal the seal's true appearance and it can be removed with a pair of tweezers.
- All metal covers in proper position before local oscillator alignment.
- Use non-metallic tool for variable capacitors trimming.
- Do not overstress plastic tool due to possible deformation, in case tool bit is deformed, use hot air blower adjusted to 110ºC and allow deformation to recover.
- Repeat low end and high end couple of times to check convergence, usually 3~4 times.

- Signal generator levels and comments

Band	Signal Level (mV)	Remarks
I	3	
II	3	
III	3	
IV	1	Took more than 10 iterations for convergence
V	1	Less stable, need to recheck BFO more often, interaction with Band IV

2-May-2010, RF section alignment Ant/RF/Mixer, Manual page 7-68, PDF page 142

- *** Manual pages instruction incorrect / incomplete, with A1 Broad Reception, there is no signal readable if Tuning generates zero beat with input signal.
- Reception mode A1 Broad.
- DC voltmeter (Fluke 17B DMM), Z1012- E to Ground (Z1012 D), note Z1012-E is negative, keep voltage reading at 0-10V, prevent overlaod.
- Signal generator to Antenna Simulator then connects to Antenna Input.
- AGC OFF, gain adjusted to approx. 5V reading at Z1012-E.
- Adjust BFO mode to ensure correct local oscillator frequency.
- Adjust ANT, RF, MIX inductors and capacitors for maximum output.



		MAXIMUM OUTPUT	MAXIMUM OUTPUT		
11	3.88	ANT COMP		ANT	I
12	3.88	C3135, C3140		RF	I
13	3.88	C551		MIX	I
14	2.1		T3101	ANT	I
15	2.1		L3135, T3135	RF	I
16	2.1		T551	MIX	I
17	7.76	ANT COMP		ANT	II
18	7.76	C3136, C3141		RF	II
19	7.76	C552		MIX	II
20	4.28		T3102	ANT	II
21	4.28		L3136, T3136	RF	II
22	4.28		T552	MIX	II
23	15.49	ANT COMP		ANT	III
24	15.49	C3137, C3142		RF	III
25	15.49	C553		MIX	III
26	8.32		T3103	ANT	III
27	8.32		L3137, T3137	RF	III
28	8.32		T553	MIX	III
29	23.62	ANT COMP		ANT	IV
30	23.62	C3138, C3143		RF	IV
31	23.62	C554		MIX	IV
32	16.32		T3104	ANT	IV
33	16.32		L3138, T3138	RF	IV
34	16.32		T554	MIX	IV
35	31.7	ANT COMP		ANT	V
36	31.7	C3139, C3144		RF	V
37	31.7	C555		MIX	V
38	24.3		T3105	ANT	V
39	24:3		L3139, T3139	RF	V
40	24.3		T555	MIX	V

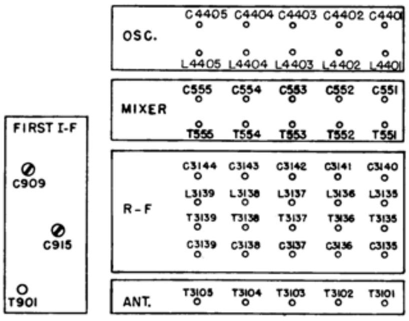


Figure 7–17. R-F Alignment Points, AN/FRR-23

Band	Signal Level (uV)	Remarks
I	10	Repeated approx 10 times
II	10	
III	10	multiple spurious and images detectable, ensure real signal is read
IV	10	Mixer pulls local oscillator
V	10	Mixer pulls local oscillator

11-Apr-2011, Installation of inrush limiting NTC thermistor
A 16 Ohm NTC was inserted between the voltage selector link inside power supply module. This reduces filament inrush current and improves tube life.